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Cover: Looking west from the Suspension Bridge across Fall Creek Gorge towards Ithaca Airport and the Lake Cayuga inlet.

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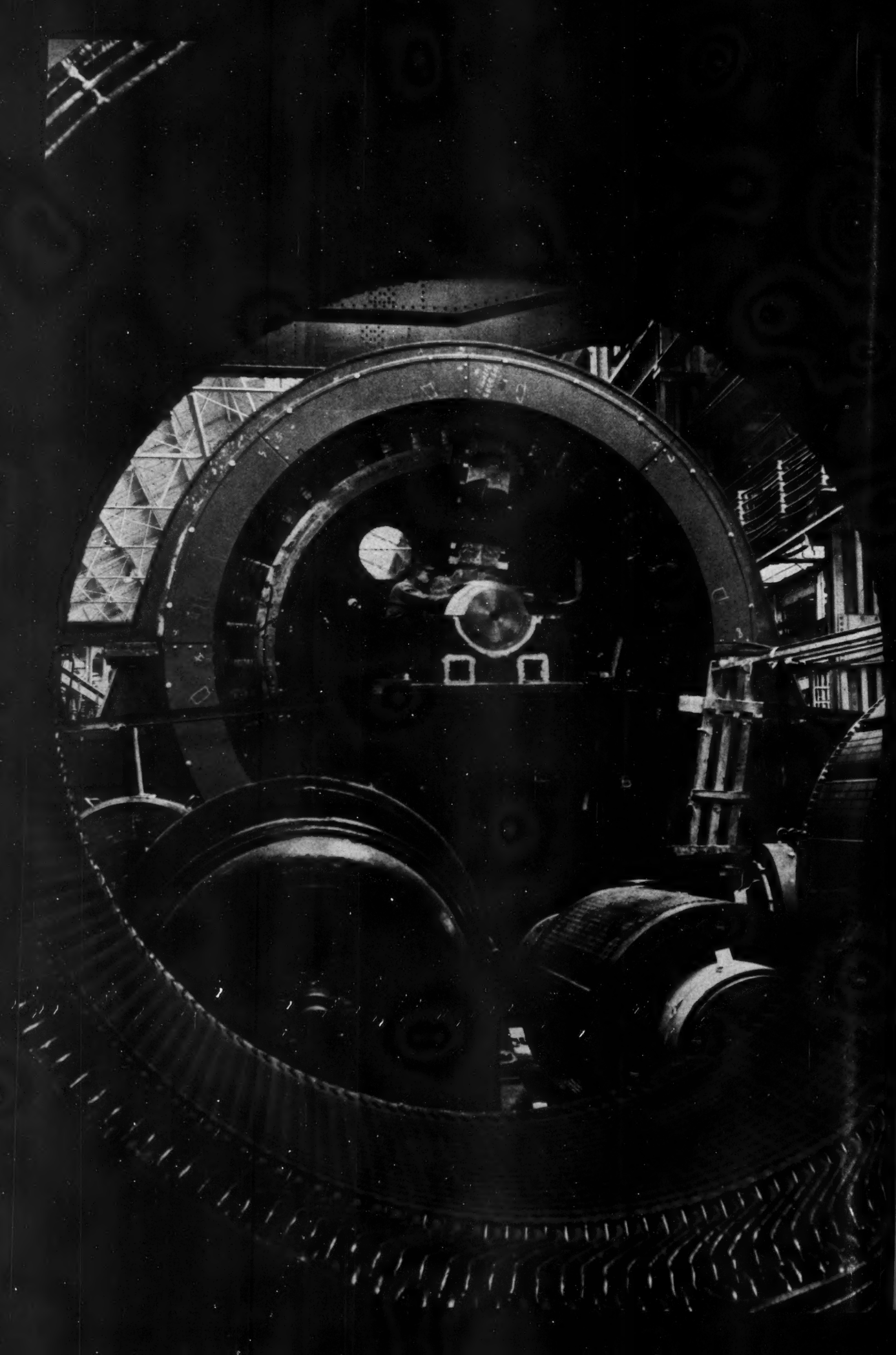

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INVESTIGATION OF BRIDGE COLLAPSE EXPANDS DESIGNERS' VIBRATION KNOWLEDGE

THE TACOMA NARROWS BRIDGE

By GLENN B. WOODRUFF, C.E. '10

THE failure, on November 7, 1940, of the original Tacoma bridge, demonstrated that henceforth designers of suspension bridges must consider not only static forces, including wind, but also the possibility of vibrations of objectionable amplitudes resulting from aerodynamic forces. The failure of the Tacoma bridge occurred at a wind velocity of only 43 miles per hour as contrasted with that of 100 miles per hour usually assumed in bridge design. Vibrations of such amplitude as to require remedial devices have been observed in four bridges of the same type, plate girders in place of the conventional stiffening trusses, as Tacoma. Vibrations of lesser amount have been observed in the two longest span suspension bridges, the George Washington and the Golden Gate. In starting the redesign of the Tacoma Narrows Bridge, those responsible were faced with these facts with little knowledge of the causes of these vibrations nor as to effective means of correcting them.

The original Tacoma Narrows Bridge, destroyed by aerodynamic forces on November 7, 1940, only four months after it had been opened to traffic.

—Courtesy Civil Engineering

Summary

While further research is required, the information developed from the investigation described below appears to justify the following:

1. Three types of vibration—vertical, torsion and binary (a combination of vertical and torsion) have been observed.

2. These vibrations may be further classified as "restricted" (or "non-catastrophic") and "catastrophic." In the former case, the amplitudes may be sufficient to be annoying and even alarming to the bridge patron but they are not sufficient to produce serious stresses. In general, they result from vortices shed at the leading edge in resonance with one of the natural period of the structure. In the "Catastrophic" class, vibrations start at the critical wind velocity. With increasing velocity, the amplitudes increase rapidly, resulting in the destruction of the bridge. They are generally torsional or binary, resulting from alternating high and low pressure areas on the upper and lower surfaces of the roadway.

3. Theoretically, any of the three type can occur in an infinite number of modes. Vertical motions with as many as eight nodes were observed on the original Tacoma bridge, and on the model. Generally, torsional and binary vibrations are of the catastrophic type occurring in the mode, fundamental or single-noded, having the lowest critical velocity.

4. The type and, to some extent, the class of vibrations which may be anticipated depends upon the cross-section of the suspended structure. This cross-section may be classified by the h/b ratio where h is the height of the stiffening girders and b their spacing. For h/b ratios between 0.25 and 0.10, vertical vibrations occur at comparatively low wind velocities; at higher velocities, catastrophic torsional vibrations occur. For ratios below 0.10, the section becomes the equivalent of a "flat plate" and above the critical velocity catastrophic binary vibrations develop. Comparatively few experiments have been made with ratios above 0.25; it is probable that in such range, vertical vibrations may become catastrophic.

5. In the usual case, it appears that the vibrations of suspension bridges with truss stiffening is controlled by the loaded deck which has flat plate characteristics. The model tests and observations on existing

A 5,000 kilowatt synchronous generator undergoing bearing adjustment. It will generate electricity sufficient to light a city of 10,000.

—Courtesy General Electric Co.

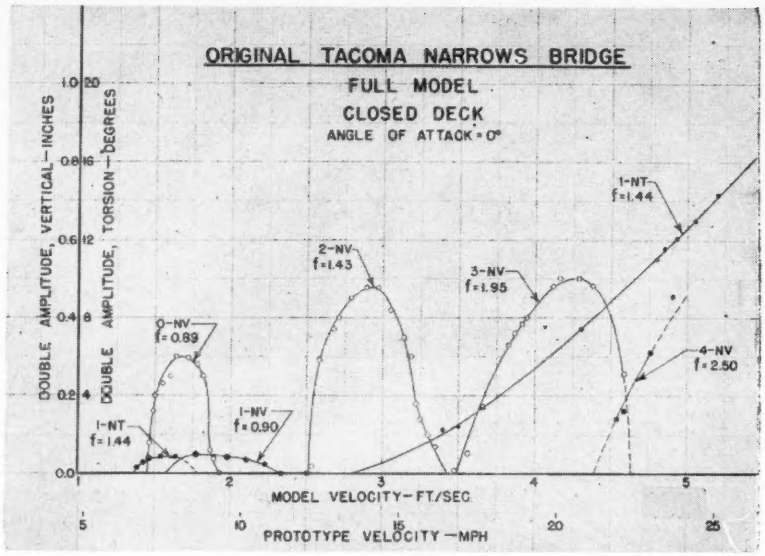


Figure 1. Results of tests on a model of the original bridge showing how five types of vertical and two types of torsional vibration varied with wind velocity. No upper limit could be determined for the torsional curve, and further increase of velocity would have broken the model.

bridges indicate that only binary vibrations occur. Probably this would not be true in bridges (e.g. the Whitestone Bridge as recently strengthened) presenting a blunt leading edge.

6. For geometrically similar sections and equivalent damping, the critical velocities are proportional to the V/nb ratio, V being wind velocity, n the frequency and b any linear dimension, commonly taken as the width of the bridge. The critical velocity may be increased by increasing the width of the structure and/or increasing the frequency.

7. The intensity of these alternating pressures producing torsional vibrations can be reduced by venting the floor as by the introduction of slots through the roadway.

8. In the lower vertical modes, the rigidity of the stiffening truss has little influence on the frequency; hence, little can be done, within practical limits, to raise the critical velocity by increasing the moment of inertia of the stiffening girders. In the case of torsion, introducing a bottom lateral system in the redesign of the Tacoma Narrows Bridge more than doubled the frequency of binary vibrations.

9. One of the main variables is that of vertical angle of attack. In the case of the plate girder sections, the largest amplitudes occur with a horizontal wind. With torsional or binary types, the critical velocity decreases with increases in the vertical angle.

10. The effect of changing the horizontal angle has not been thoroughly investigated. It is believed that in most cases the worst case is with wind at right angles to the bridge, although there is some evidence that, in some cases, the bridges are most responsive to a quartering wind.

11. Three classes of damping must be considered—negative air, positive air and structural. Negative air damping is merely another term for aerodynamic instability and causes the forces producing the vibrations. Positive air damping results from the resistance of the air to the movements of the structure. Structural damping, generally measured by the logarithmic decrement, results from solid friction such as that at the bearings, and the internal friction, hysteresis, set up by the alternating stresses during vibration. The negative damping is opposed by the other two.

Quantitative Information

Little quantitative information is available as to these forces. We know that the structural damping of a suspension bridge is very low, the logarithmic decrement being in the general order of 0.05. With vertical vibrations, fairly close approximations can be made as to the positive air damping. When the vibrating system reaches a "steady state," the negative air damping equals the sum of the other two, hence it is possible to estimate the energy transferred from the wind stream to the vibrating structure. In the case of catastrophic vibrations the steady state is never reached. It is theoretically possible to measure the logarithmic increment as the amplitudes increase. However, above the critical velocity, these amplitudes build up so rapidly that measurements are impractical. The critical velocity increases, to some extent, with increased structural damping.

12. In a "steady" windstream increasing either or both the rigidity and mass of the structure would increase the time required for the vibrations to reach a given amplitude. In addition, it may be assumed that the material comprising this mass would add to the structural damping. However, in nature, the wind is not steady but constantly varying in force and direction. For these reasons, increased rigidity and mass are desirable. It appears, however, that the provision of greater rigidity and mass than are required for other

THE AUTHOR

Glenn B. Woodruff entered the bridge construction field shortly after graduating from Cornell in 1910. As a principal assistant engineer in charge of the designing office of Modjeski and Masters, Mr. Woodruff's experience encompassed the bridge design and structural fields. From 1931 to 1940, he worked on the design and construction of the San Francisco-Oakland Bay Bridge. Following his service on the Board of Engineers which investigated the failure of the Tacoma Narrows Bridge, Mr. Woodruff, between 1941 and 1947, was a consulting engineer for the redesign project. During that period he established the partnership of Woodruff and Sampson in San Francisco. Mr. Woodruff holds membership with numerous professional societies and advisory committees.

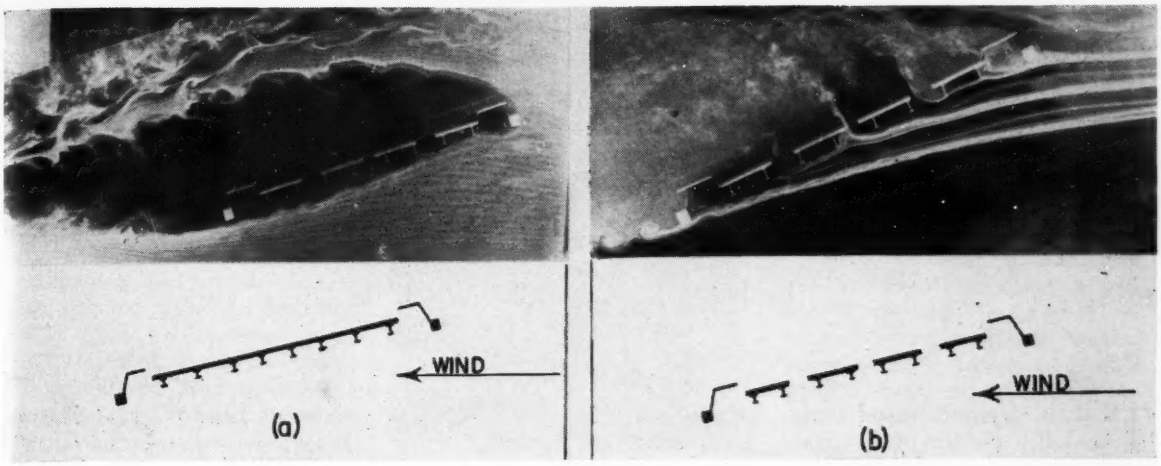


Figure 3. Smoke tests on seventy-six models of roadway cross-sections indicated that model (b) was the most satisfactory in a high wind. The large area of reduced pressure produced above the original cross-section (a) is reduced by installing open gratings in the roadway.

reasons is an expensive means of securing aerodynamic stability.

13. Summarizing the above, it appears:

(a) Vertical vibrations can be inhibited by adopting a truss stiffening system with care taken to avoid blunt leading edges, or in other words, selecting a horizontal flat plate insofar as aerodynamics are involved.

(b) With a solid concrete roadway, the critical velocity can be raised above that of any probable wind by increasing the width of the structure and/or by increasing the torsional frequency by the introduction of a double lateral system.

(c) The aerodynamic stability can be increased by venting the floor to relieve the unbalanced forces.

The Investigation

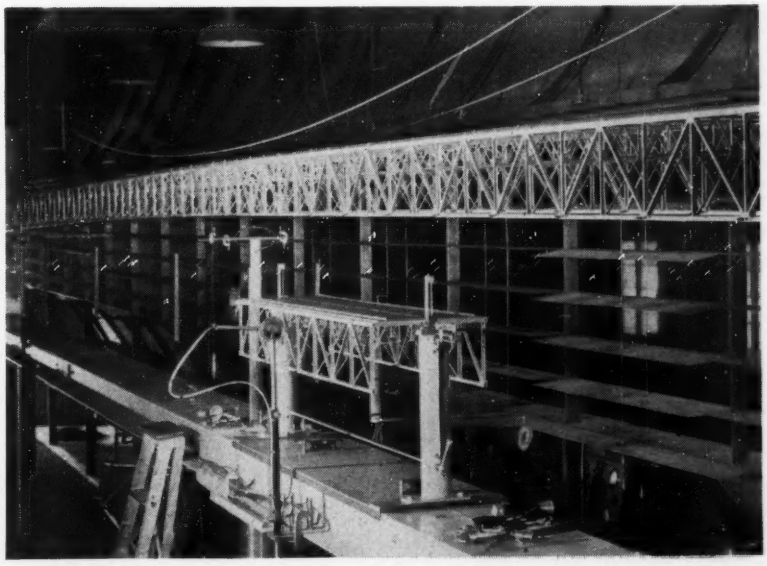
Before the failure, investigations were under way at the University of Washington in an attempt to develop means of controlling the vibrations which were occurring. After the failure, further experiments were conducted at the California Institute of Technology under the auspices of a Board of Engineers appointed by the Public Works Administration to investigate the failure of the bridge. Upon starting the redesign, research was resumed at both of these institutions; the program culminating in the construction, at the University of Washington, of a wind tunnel with a throat 100 ft. long and 4 ft. high. The throat was equipped with vanes permitting a range of $\pm 15°$ in the vertical angle of attack. Sufficient propellers were installed to furnish an uniform flow over the entire 100 ft. length at a velocity of 17 mph corresponding to a velocity on the prototype of 118 mph.

The models have been of two classes—full length and sectional. The first are true to scale in regard to shape, weight and elastic properties both vertically and in torsion.

There are two properties which it is impossible to reproduce to scale —damping and Reynolds Number. The structural damping of suspension bridges is very small, the logarithmic decrement being in the general order of 0.05. In the model construction, friction was reduced to a minimum so that the error from this source is probably negligible. It is impractical to reduce Reynolds Number on a small scale model. However, both the correlation between the observations on the original bridge and the results on the model thereof and the fact that this factor is generally of little consequence on blunt surfaces indicate that Rey-

(*Continued on page 26*)

Figure 2. Wind tunnel and models. Throat of the wind tunnel appears at right with vanes to control vertical angle of attack. The full length model (above) is raised above the wind stream, while the section model is in position for testing.



UTILIZATION OF RICH
WATERPOWER RESOURCES

Norway's White Coal

By WILLIAM F. KANN, CE '48

TEN or eleven thousand years ago when the last of the great continental glaciers completely covered the land we now call Norway, it created a geological imprint which was to determine the way of life of the Norwegian peoples. From the northern tip of Finnmark to the southern tip of Islo Fjord, the geology of Norway is characterised by thousands of miles of fjords, U-shaped valleys, high mountain ranges and wide plateaus. When the glacier retreated northward, it left countless lakes and streams fed partly by glacial waters and partly by a rainfall which ranges from ten inches to one hundred and fifty inches every year. This potential energy in water power, which was made possible by the continental glacier, has been estimated at eighty billion kilowatt-hours per year.

The Norwegian people first began to tap this tremendous source of energy as early as 1280 A.D., when water power was harnessed to create mechanical energy. That was the beginning of Norway's gigantic wood pulp and paper industry. Since then, water power has assumed a major role in creating mechanical energy, but it was not until 60 years ago that the first hydro-electric plants were built. Today, Norwegian industry is using 11.5 billion kilowatt-hours of hydraulic energy per year. Fifty three percent of this energy is used in the metallurgical industries, of which the refining of metals from their ores is the most important. Twelve percent is used in the pulp and paper industry, ten percent for mining and the handcrafts, one percent for electric transportation systems, and twenty-four percent for civil consumption.

One of the most famous of the Norwegian waterfalls was the old waterfall called Rjukan. This waterfall, whose energy is now used by the Norsk Hydro Company drew its water from the far reaches of the Hardanger plateau, from the fast mountain streams which feed into Lake Mosvann, the Rjukan waterfall's natural reservoir.

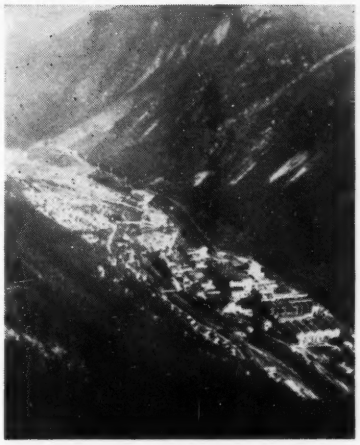
Lake Mosvann has been widened and deepened by a dam which now holds back 1064 million cubic meters of water. This dam is approximately 19 meters high and consists of thin front and rear reinforced concrete walls supported by buttresses. From Lake Mosvann to the sea, the water flows through different sets of tunnels and turbine pipes which provide the turbines with the power they require.

Transmission lines, carrying power to Norwegian homes and factories, scale the steep valley walls above Rjukan.

Course of Mosvann's Flow

The water first flows through a tunnel connecting Lake Mosvann with the Fröistul power station where turbines develop 34,000 h.p. It is then gathered into the river Maana flowing down to Skarsfos, the site of the old Rjukan waterfall. Here another dam has been erected, and the water enters a tunnel in the mountain side and flows for about 5 kilometers into 11 turbine pipes which terminate at the Vemork power station after a fall of 300 meters. This power station develops 200,000 h.p. The water then passes through another tunnel 5 kilometers long and flows down 275 meters through pipes to the Säheim power station where it develops 160,000 h.p. The power originally stored up by the mountain streams on the great Hardanger plateau has now been largely reclaimed, and the water flows back into the river Maana and continues slowly on its way through the Vestfjord valley.

In this valley surrounded on the north and south by steep mountain sides rising to a height of 600 meters, the Rjukan nitrate factories cover an area of more than 10,000 square meters. All the power developed in the Vestfjord valley is used for the fixation of the nitrogent of the air and for converting it into nitrogenous fertilizers. The oldest method used was developed by the scientist Birkeland and the engineer Eyde who harnessed the Rjukan waterfall during the years 1903 to 1905 for their source of power. This first method of using Birkeland-Eyde furnaces with their discs of flame in which nitrogen and oxygen are combined to form nitric oxide is still being used.



Rjukan's many industries are powered by water from Lake Masvann, a reservoir which holds back more than a billion cubic meters of water.

Improved Method Adopted

Recently, however, a more efficient method has been adopted. In this process nitrogen and hydrogen are combined to form ammonia. The bulk of the hydro-electric power developed is now used in two new plants erected in 1928 and 1929 using this second process. The factories at Rjukan produce 200,000 tons of nitrate of lime annually, great quantities of liquid ammonia, concentrated nitric acid, and several by-products such as the inert gases, dry ice, and heavy water (deuterium oxide, a by-product when producing hydrogen by the electrolytic decomposition of water).

Leaving the valley of Rjukan, the river Maana flows through the Vestfjord valley to Lake Tinnsjo. A dam has been erected at the southern end of this lake which enables 200 million cubic meters of water to be stored in the lake, thus providing a source of power for the lower-lying power stations. This water power develops 60,000 h.p. at the Svaelgfos power stations, which are the oldest plants of the Norsk Hydro Company, and 20,000 h.p. at Lienfos. The water then flows on to Notodden where the world's oldest factory for the synthetic production of nitrogen fertilizers is situated. Here, too, are located more Norsk Hydro nitrate factories and factories for the production of packing materials and impregnated bags.

Other Norsk Hydro plants are the Eidanger factories located at Heroya which produce 250,000 tons annually of nitrate of lime and Calnitro. The liquid ammonia received from Rjukan is used in the latter process. Another plant erected near the Eidanger factories produces 75,000 tons annually of sulphate of ammonia and 20,000 tons annually of nitrate of soda.

Besides these factories, Norsk Hydro owns and controls large store houses, quays, ferries and railroads. The company is still expanding. Its latest project (called Maar-kraft-anlegg) is a power station located inside of the valley wall at Rjukan. Here a huge cavern has been blasted out of solid rock 80 to 100 meters inside the valley wall. The power station located in this cavern is fed from water stored on the plateau on the far side of the mountain and will develop 200,000 h.p.

The Rjukan waterfall (whose water now runs the Norsk Hydro factories) is the most famous of Norway's white coal sources. However, Norway has many others, including those in the West in Hardanger fjord and Sagnefjord where ten percent of the total water power in Norway is located. Today, Norway has realized 15 percent of her total available power. The uniform annual increase in water power has been 40,000 kilowatts with a total output in 1946 of 11.5 billion kilowatt hours.

Unlike our TVA water power system, few plants in Norway are run by reservoirs of dammed up water. The maximum height of dams in Norway is 120 feet and most dams are only 50 feet in height. This is mainly because of geological formations, the high plateaus, mountain ranges, and deep valleys providing natural storage tanks for the water which can be tapped by tunnels bored through solid rock. Norwegian lakes are long and winding and the outlets are so narrow that an immense amount of water can be stored behind a small dam.

The conditions of rainfall and geology are such that large storage areas are not necessary for flood control or to provide relief for a

(*Continued on page* 30)

Penstocks bring water from Lake Mosvann to the turbines in the famous deuterium (heavy water) plant at Rjukan.

PROBLEMS IN MODERN
OFFICE BUILDING CONSTRUCTION

Constructing a New Skyscraper

By CHARLES M. CHUCKROW, C.E. '11

PRIOR to 1946 no skyscraper office buildings were erected in the Greater New York area since the last of the Radio City Buildings was completed in the middle thirties. At that time manpower and materials were in plentiful supply and costs were low. Early in 1946 two large buildings were projected, one being the 33-story Esso Building at Radio City, the other being the 22-story Universal Pictures Building occupying the block front Park Avenue, 56th to 57th Streets, owned and built by the Tishman Realty & Construction Company with whom the writer was then associated.

The main problems involved in the latter operation were:

Designing a building incorporating ideas sufficiently advanced to meet the competition of future buildings, and flexible enough to meet the tenant change requirements of expected long-term lessees;

Coordinating the air conditioning system with the other trades affected by it;

Negotiating favorable sub-contracts in the face of uncertain material prices, changing labor rates, and escalator clauses;

Coping with unforeseen foundation conditions;

Marshaling of scarce manpower and materials;

Expediting the fabrication and delivery of manufactured products;

Obtaining Civilian Production Administration permit to proceed;

Securing a building permit while litigation was pending in the State Courts to determine which zoning regulations applied.

The building occupies a plot 200′ on Park Avenue x 90′ on 56th and 57th Streets. Set-backs start at the 12th floor. The rentable areas diminish from 15,000 square feet on the lower floors to 3,000 square feet on the top floor. The total rentable area above the ground floor is 245,000 square feet. The entire building is provided with a zoned air conditioning system. There are two refrigerating units of 500 tons capacity each in addition to which there are individual units for the Salvin Resaurant and the Bankers Trust Company quarters. It is a steam turbine driven system fed from the New York Steam Company mains. Air is distributed through galvanized iron ducts below the floor arches. The zoning system was necessary to take care of the extremes between westerly exposure subjected to the hot afternoon sun on the Park Avenue frontage and the interior areas which are subjected to no exposure.

Limestone Facing

The street and avenue fronts from the second floor up are faced with a 4-inch thickness of Indiana Limestone. The slabs extend from the window heads of one story to the sills of the next story.

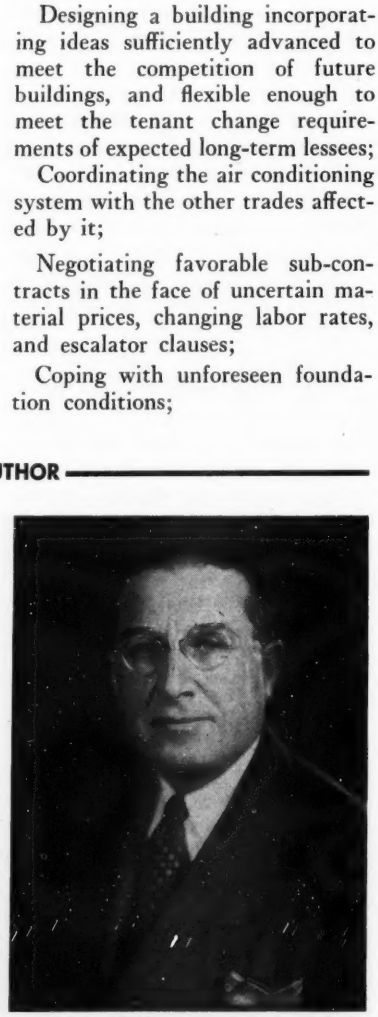
Because the rear wall is visible on the easterly side from great distances, it is faced with a light

THE AUTHOR

A past President of the Cornell Society of Engineers, Charles M. Chuckrow has been prominent in the construction field almost from the time of his graduation from the School of Civil Engineering in 1911.

Among Mr. Chuckrow's more notable works have been the 70-story Chrysler Building, the Westinghouse Building in New York, and many other office buildings, in addition to housing projects, industrial plants, hospitals, banks, and college buildings. During the war, he served on the War Department Price Adjustment Board, and is at present associated with Fred T. Ley and Company in the capacity of president.

Mr. Chuckrow is a member of the Engineering College Council at Cornell. He was an associate editor in the preparation of the textbook, "Reinforced Concrete and Masonry." A more complete biography may be found in Vol. 12, No. 8, p. 15 of the ENGINEER.



Charles M. Chuckrow

glazed face brick. The store fronts from street grade to second story spandrels are of stainless steel.

The windows are of unusual design and were built around the so-called strut system. Instead of the usual H columns on 20′ centers with bulky masonry fireproofing, a slender T column was used on approximately 9′ centers. This added to the cost of steel because of the l/r factor. The steel window units are slightly less than 4′ wide and the window frames are covered on the exterior by a stainless steel mullion. The resulting appearance is that of continuous windows which, together with the horizontal limestone spandrels, constitute what the architects of the building call ultra modern streamline design.

The vertical steam risers and returns run up in vertical pockets half-way between the struts. The mullions forming the fronts of these pockets are the same design and width as the mullions covering the struts.

One of New York's newest skyscrapers, the Universal Pictures Building rises twenty-two stories above Park Avenue. Owned and built by the Tishman Realty and Construction Company, it embodies many unique innovations.

Heating System

The heating system is a two-pipe vacuum. Because of the shortage of cast iron and copper convectors, the heating contractor installed toncan metal convectors which he had specially made in a shop previously devoted to the manufacture of automobile radiators. Radiators are fully enclosed with a sheet steel cover extending from column to column.

An interesting decision had to be made with respect to the heating plant. A high pressure plant would have cost about $85,000. New York Steam Company rates are graded down depending on volume of steam used and a minimum charge is made during the summer months. The plant has to be run in summer to provide hot water but the charge is greater than the value of the steam used for this purpose. However, because of the huge steam load required in summer for the air conditioning system, the cost of steam per M lbs. diminishes and the uneconomical summer minimum rate disappears. It was, therefore, decided to use street steam. However, a boiler room and stack have been provided and if street steam in future years becomes uneconomical, a heating plant can be installed.

The building is equipped with eight high speed, full automatic, push button elevators with power operated center opening doors. Four local elevators go to the 13th floor and four express elevators to the upper floors. In modern office buildings a ground floor interval of twenty-five seconds should be maintained. The eight elevators should maintain this interval under normal conditions, but the decision had to be made long before the occupancy load was known. An additional elevator would cost almost $50,000. and there was a reluctance to spend this money unless future occupancy would substantially exceed normal expectations. As a precaution, therefore, an additional elevator shaft was built. If the load should become excessive an additional elevator can be installed with minimum disturbance to the tenants and there will be no problem of recapturing space already rented.

The structure is the skeleton steel, short span type of construction with "Gritcrete" arches. The girders span from column to column and the intermediate beams are spaced from 7′ to 8′ apart. "Gritcrete" is an outgrowth of cinder concrete arch construction but

(Continued on page 36)

IMPENETRABLE OBJECTS FOR IRRESISTIBLE FORCES

Development of Armor Plate

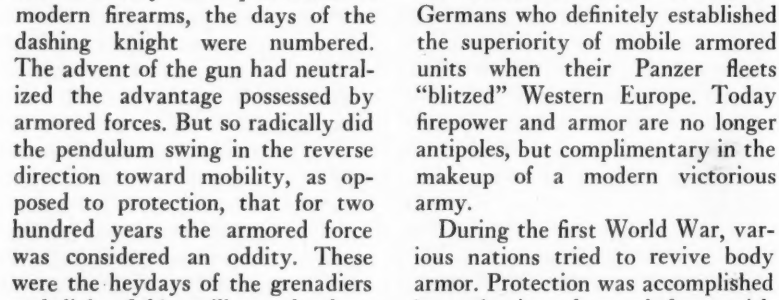
By JACK G. DORN, ME '49

IN the days of knighthood, light armor permitted the one-horsepower prototypes of our modern tanks to overrun most of civilized Europe. Nothing instilled such terror into the hearts of the defenders as a waving line of armored cavalry enveloping a battlefield. But with the discovery and perfection of modern firearms, the days of the dashing knight were numbered. The advent of the gun had neutralized the advantage possessed by armored forces. But so radically did the pendulum swing in the reverse direction toward mobility, as opposed to protection, that for two hundred years the armored force was considered an oddity. These were the heydays of the grenadiers and light field artillery, the long rapid marches and fast charges. It was truly blood against steel.

Looking backward over these troubled years, it seems rather strange that the advances in metallurgy which had made the armored ship worthwhile were not more quickly put to use by land forces. The appearance of the tank in the first World War was long delayed and, undoubtedly, did change the method of land warfare. It was the Germans who definitely established the superiority of mobile armored units when their Panzer fleets "blitzed" Western Europe. Today firepower and armor are no longer antipoles, but complimentary in the makeup of a modern victorious army.

During the first World War, various nations tried to revive body armor. Protection was accomplished by a laminated metal form with sponge rubber at the joints, for resistance against low and middle velocity projectiles. The general results were not satisfactory, and only the helmet was retained. Armor for arms and legs, while produced in experimental lots, notably in France, was not recommended for active service.

Charging end of a gas-fired furnace in which armor plate is heated prior to die quenching. *—Courtesy Steel*



Modern Armor

The story of modern armor plate begins with the use of iron clad warships. In 1812, John Stevens of Hoboken, N. J., determined the laws of penetration of iron plates by cannon balls and the maximum thickness required to defeat any known gun. Little came of these investigations, however, until the publication of some notes by Stevens' sons attracted the attention of Congress, which, in 1854, resulted in the building of the first armored ship, the *Stevens' Battery*. The armor consisted of four to five inches of wrought iron (the only kind produced in large enough quantities at that time) backed by thirty-six inches of wood timber.

Continued investigation showed that single plates gave greater protection per pound of metal. Laminated armor was first used in the Civil War, during which time the first engagement between armor-clad naval vessels occurred.

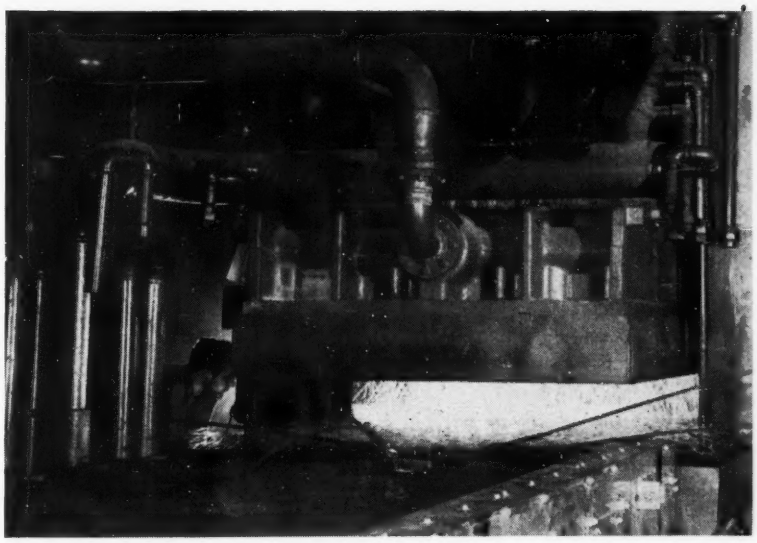
Through the following years, there continued a search for a plate with a hard surface and tough interior which was known to be necessary to beat the guns of the day. The progress was hampered by lack of metallurgical knowledge, but a compound armor consisting of wrought iron back plate and an open hearth steel face was evolved. Great competition and controversy existed as to the relative quality of all steel and compound armor.

Toward the end of the nineteenth century, rapid strides began

to be made. In 1889, Schneider and Cie introduced a four per cent nickel steel armor which was followed in 1890 by the famous Harvey process. This consists of case carburization of the steel plate, followed by a water quench from a high temperature. Finally there resulted a nickel steel, cemented, water sprayed, oil tempered, face-hardened armor known as Harveyized. This was one of the first standardized manufacturing processes and attained wide popularity. But the greatest advancement was yet to come.

In 1893, the great industrial iron and steel works of Krupp perfected an armor plate which soon swept all rivals before it, and became internationally recognized as the acme in armored protection of the day. The armor consisted of a nickel-chromium steel carburized with gas, and hardened on one face. Each sheet of armor was packed in a deep clay with only the face to be hardened exposed. A quick, though intense, heat was applied to this face, and then a fine water spray quench was directed on both sides of the plate. This treatment of "decremental face-hardening" produced a hard outer surface, one-third the thickness of the plate, the back remaining in the original tough condition. This armor was so good, that all manufacturers soon adopted it. By 1900, all U.S. vessels were K.C. (Krupp cemented) armor clad. Most of the armor produced even today, is manufactured by the basic Krupp process.

During all this time, numerous experiments were made in the effort to produce novel types that would effect a saving in weight and cost of armor. Target structures of almost every conceivable description were made and subjected to ballistic tests. There were homogeneous cast-iron and wrought-iron plates, and built-up targets of every description, including sheets of metal bolted together and presented flat or edgewise, alternating layers of metal and wood, of metal and rubber disposed in various ways, and of springs behind solid plates and between the laminations of built-up plates. The targets were fired at vertically, and inclined at various angles.



Only three to eight minutes are required for this 2,500-ton hydraulic press to complete a cooling and straightening operation which will prevent distortion of the plate after it has been quenched.

—Courtesy Steel

These experiments demonstrated the following general principles:

(1) To be efficient, armor must be homogeneous as to mass, so as to concentrate the resistance.

(2) Armor should be rigidly attached to the structure, and devices such as springs or rubber cushions do not add to its resisting qualities, but are in reality a source of weakness.

(3) Inclined armor, designed to deflect the projectiles upon impact, is, for purposes of protection, about equal to vertical armor of equal weight.

Effect of Elements

Various elements and their combinations have different effects upon the physical properties of armor plating. Increasing the carbon content of the basic steel, increases the manufacturing difficulties by making the plate more brittle, accelerating tears in the forging, and making "fibering" more difficult. "Fibering," as used in armor plate terminology, has a different connotation than in metallurgy. To fiber the softer backing of an armor plate means that a piece cut therefrom will have a fine grained, silky fracture, and indicates that the grains in the backing will deform on impact instead of rupture. This quality is very desirable since such a structure will absorb a greater amount of energy. The addition of nickel enhances the attainment of this fibrous condition, besides increasing the toughness. Chromium achieves hardness with less brittleness than with carbon, and also facilitates the decremental water hardening.

There are, in general, two distinct types of armor; face-hardened or carburized, in which carbon is added to one surface of the plate; and homogeneous armor, which is uniformly hard throughout, but not so hard or resistant to shell fire as face-hardened armor. Both types employ accurately controlled electric furnace alloy steel. Face-hardened plate is highly specialized and therefore extremely costly. It requires the perfect blending of temperature, time, quenching, tempering, drawing, etc., to produce an armor which can meet war department specifications. Samples of such armor are ballistically tested, and if they fail are the source of great loss to the manufacturer.

The manufacture of modern face-hardened armor comprises a series of operations which require the greatest care and attention to details to produce the best results, and these operations are so elaborate that a period of nine months is allowed in the manufacture of service armor from the time of the receipt of the original drawings until the completion and delivery of the plates. The steel is carefully

prepared in the open hearth furnace and poured into iron or sand molds. The ingot is reheated, after being stripped from the mold, and hydraulically forged to fifteen per cent of its final desired thickness. The segregated impurities in the upper portion of the plate are now discarded, and the forging is then annealed to produce a partially "fibrous" condition. It is furnace cooled to prevent cracking and to eliminate strains due to the forging operation.

Now the plate is ready for cementation and is placed in a large iron case, in which is a bed of clay. It is buried to more than half its depth, the surface being covered over with a carbonaceous material, and heated from ten to fourteen days in a closely controlled furnace. The pack carburization of the surface produces a graduated carbon content from the surface to the interior by diffusion. Reheating, reforging, and annealing, followed by several heat treatments, are the final steps before it is machined to its rough dimension. It is then reheated, formed to its final shape, and casehardened by water spraying on both sides, to prevent warping. The curvature of the plate is rectified by tempering, after which it is machined to the finished dimensions.

The manufacture of armor plate has for centuries required much time. There has been little development, except for metallurgical, in the past hundred years until the advent of light armor in the past war. Light armor was not used from the Middle Ages to the Spanish Civil War, but since then it has successfully been applied to protect warplanes, shield instrument panels, engines, radios, installations, etc. Light alloys have the ability to resist penetration by bodies at high velocities, but what is more important, reduce risk against secondary dangers of fragmentation, prevalent with steel armor plate. When a projectile strikes, the alloy exhibits the properties of a sandbag, reluctantly yielding and "spending" the energy of the projectile by mutual deformation, until, ultimately, it completely embraces the projectile and absorbs its kinetic energy. Hardened steel, on the other hand, would tend to cause a rebound, ricocheting the projectile and possibly causing danger.

Production Time Cut

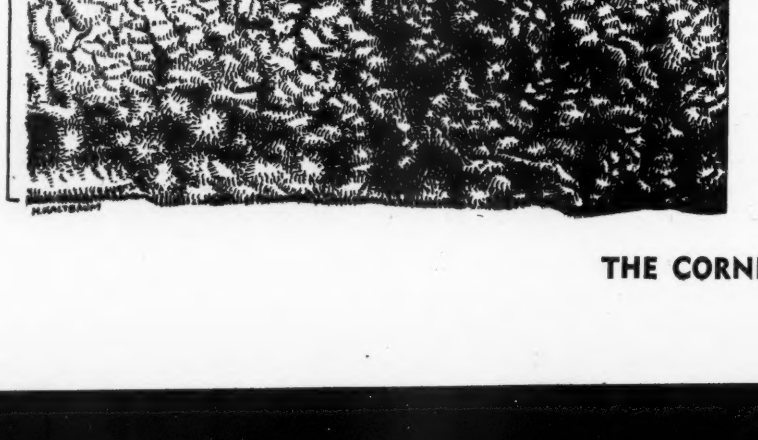
During the past war, the demand for armor plate was obviously very urgent. The large amount of time and care required to make a suitable plate was a stumbling block which had to be overcome. Previously, batches of armor were produced in lots on order; but now, continuous production of high quality was necessary, without too great a loss in time. Naturally the demand of mass production changed the method of manufacture. No longer was it produced in job lots, but a "straight line" system of hardening, quenching, degreasing and tempering was installed. Each unit was an integral part of the entire line. The result was that time was cut radically, efficiency improved, and quality not in the least affected. Mass production made available new avenues of manufacture which would have been entirely unavailable had not quantity entered the picture.

The major problem in the heat treatment of armor plate is distortion. The plate must be mechanically straightened after the quenching operation at a great expense in time and money. Mass production quantity makes available the use of a "pressure quench," in which the plate is sprayed between two large pressure jaws, and therefore the curvature of the plate is held to a minimum. The plate emerges from a continuous roller hearth furnace, and a uniform pressure on both faces is exerted, with the spraying water emitted from the pressing unit. Such processes, made available by wartime necessity, have become a standard manufacturing method in peacetime armament industries.

The manufacture of efficient armor requires not only a high quality of metallurgical skill, but also expensive tools and equipment. The various improvements in its quality and manufacture have, therefore, been as closely related to the inventions and discoveries of metallurgy as to the commercial growth of the general steel industry.

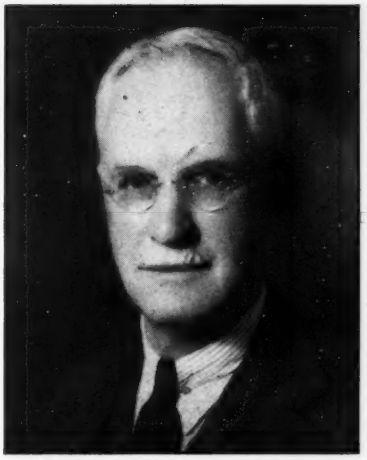
Sketch of a coupon from ten-inch armor plate showing the results of heat treating. The combination of three sets of properties in the cross-sectional layers gives the steel optimum resistance to penetration, buckling, and destruction.

—Henry Jameson, Jr.



DIRECTOR WILLIAM LINDSAY MALCOLM

CIVIL ENGINEER, SOLDIER, ATHLETE, HE SERVED TWO NATIONS WITH DISTINCTION



Dr. William Lindsay Malcolm, director of Cornell's School of Civil Engineering since 1938, died on Sunday, January 18, less than three days after a heart attack. Dr. Malcolm had become ill during a dinner party held the preceding Thursday for graduate students from his native Canada.

Born in Mitchell, Ontario, Dr. Malcolm came to Cornell from Queens University, Kingston, Ontario, where he had served as assistant professor of civil engineering from 1907 to 1914, and, subsequently, as professor of municipal engineering until his appointment at Cornell. He also held city engineering posts in Canada and did occasional contract work, principally on highways.

Queens University awarded him the degrees of Master of Arts in mathematics and Bachelor of Science in Civil Engineering in 1905 and 1907, respectively. He later did further graduate work at Cornell during the summer months and in absentia, receiving the degrees of Master of Civil Engineering in 1934 and Doctor of Philosophy in 1937.

During the first World War, Dr. Malcolm served overseas for five years as a divisional commanding officer of the Canadian Army Engineers. He attained a lieutenant colonelcy, a rank which he maintained in the Reserves until his death. Based on these experiences was an article on the "Wartime Functions of Engineer Troops," which appeared in the CORNELL ENGINEER of April, 1942.

As an avid and adept athlete all of his life, Dr. Malcolm felt acutely the ban on further athletic activities that was necessarily imposed following his first heart attack three and a half years ago. He often opened a freshman orientation lecture with a challenge to thoroughly trounce anyone, anytime, at his favorite sport — badminton. He served for a time as president of the Canadian Badminton Association.

Age (sixty-three at the time of his death) did not hinder his athletic prowess, and he retained the enthusiasm and ability of youth in golf and badminton competition. He performed notable coaching duties with the football and baseball teams at Queens, while his tennis game brought him several trophies.

Dr. Malcolm's less strenuous pastimes were confined largely to crossword puzzles and a rugged game of bridge.

A hydrologic study of Ontario, Canada, was Dr. Malcolm's "pet project" for fifteen years. He had carried on research and collected data for those many years considerably handicapped by lack of time. The Christmas holidays were spent in assembling the concluding rainfall and watershed data. The anticipation of completing the extensive paper within the next month or two was highly gratifying to Dr. Malcolm. Unfinished tasks had always vexed him, and it is indeed unfortunate that he could not see completion of this work, and the manifestation of more of his hopes and plans for the Civil Engineering School.

The sanitary engineering laboratory at Queens that Dr. Malcolm designed has long been acclaimed one of the finest on the Continent. Similar facilities which he had designed for Cornell have long been held in abeyance, pending sufficient funds.

Director Malcolm gave unstintingly of his energies during the war, carrying a full teaching load in addition to his administrative duties with a naval research project and the School. His memberships in numerous societies and honoraries were never neglected.

Dr. Malcolm was so enmeshed with his duties as director of the School that he never had a real opportunity to develop into a "character." He was known by his students for his interest in them as individuals, to any of whom he was readily accessible and always ready with a bit of tolerance, a suggestion, or a word of encouragement. Loss of his own son many years ago had but expanded his fondness for young people.

With Dr. Malcolm's passing, the students have lost a true friend, the University has lost a fine educator, and the profession—a fine engineer.

The Editor's COLUMN

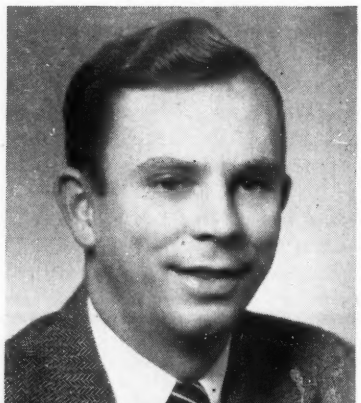
Let's Celebrate

It has long been our contention that the trouble with engineers is that they too often tend to become the dull, over-conscientious grinds that students in other schools claim they are. We agree that there's excuse for this; namely, that the engineering student has, on the average, quite a bit more work to do than his fellow Cornellians in other colleges. We don't, however, feel that this is any reason why the engineers shouldn't have a little more of the spirit of unity and good fellowship that gives such organizations as fraternities, societies, and even some colleges of the University a much more friendly and congenial atmosphere than one finds in the halls of Franklin and Sibley.

We're not accustomed to criticising our fellow engineers so severely, but we have what we think is a very good idea and we'd like to enlist some help in putting it over. It's our firm belief that what this college needs is a good annual celebration, a day dedicated to the 3000 engineers to give them a chance to relax, blow off steam, and be proud of themselves. There are many precedents for this—on many college campuses, St. Patrick's day is set aside as Engineers' Day; and for years before the war on March 17 our own quadrangle was the scene of a healthy tussle between the engineers and architects.

It seems to us that some sort of an engineers' celebration would not only be beneficial to all of us, but would be enthusiastically welcomed, once the idea got started. Frankly, we don't know just what kind of affairs is wanted, that is for you to decide. We'll be glad to join anybody or any organization that feels the way we do and wants to promote something; just drop up to 400 Lincoln or call us on Ext. 2100. Let's show the rest of the campus that the engineers are still alive!

PROMINENT



Ray

Raymond E. Tuttle, ChE

Born in Negaunee, Michigan back in 1923, Ray managed to stay in one place until he was old enough to walk, and then started a series of moves from town to town that stopped only when he entered Cornell. He attended fourteen different schools in five different states before graduating from high school. He claims, "he just couldn't find a school that would give him a diploma." Saugerties, N.Y., finally came through with a diploma in '41 which convinced him. He now lives in Shaker Heights, Ohio.

He entered Cornell in September 1941 in the School of Chemical Engineering. The first two and a half years he lived in Cayuga Lodge, a cooperative association on the hill, and was house president his sophomore year. In between chemistry labs he played tennis—making the team his freshman and sophomore years.

Ray entered the Army in 1943 and moved from the Artillery to the Signal Corps and then to the European and Pacific Theaters.

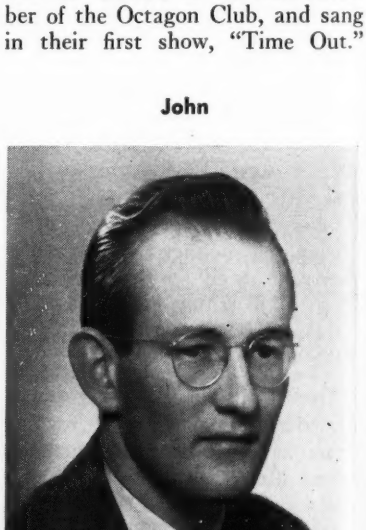
When he returned to Cornell in 1946 he joined Alpha Delta Phi fraternity. He has been very active on the house athletic teams and served as the house manager last year. He says that the athletics keep him in shape for those three flights of steps up to his laboratory in Olin. Most of his spare time is now devoted to the activities of Tau Beta Pi, of which he is vice-president. But you'll also find him wandering around AIChem E and Al Djebar parties with the inevitable beer in his hand. Scholastically, Ray's been on the Dean's Honor List most of the time since he came here, and has held the New York State, Cornell, and McMullen scholarships.

John D. Saunders, CE

Having never seriously considered any other career or college, John entered Cornell's School of Civil Engineering in the fall of '44, and from the very first participated in a great many extracurricular activities. This seems to be right in line with his record at Long Island's Great Neck High School where he acted as treasurer for the student governing body, and participated in varsity football, baseball, and basketball.

He continued his interest in the latter sport by playing J.V. basketball during his freshman year. He was also elected an associate member of the Octagon Club, and sang in their first show, "Time Out."

John



This musical interest continued during his sophomore year, when he sang in the Men's Glee Club.

That same term, John found time to engage in campus politics with singular success. In the spring he was elected for a two year term to membership in the Student Council, as well as becoming President of the class of '48 for the ensuing two years.

Somehow, John managed to keep up with his studies so well that during his sophomore and junior years, he received three McMullen Regional Scholarships.

John has also had his share of recognition from the various honor societies on campus. During his junior year, he was elected to Rod and Bob, Civil Engineering social-honorary, as well as to Chi Epsilon, Civil Engineering national honor society. He was also made a member of Tau Beta Pi, national engineering honorary, while still a junior. His own fraternity, Phi

(*Concluded on page* 32)

Ansley W. Sawyer, ME

Getting away from Sibley seems to be the best angle on becoming a "prominent engineer" as well as joining the ranks of Cornellian BMOHs as far as "Pete" Sawyer is concerned.

Just in the way of history, Pete came to Cornell from Deerfield Academy for the first wartime summer session in '42, and thanks to the attraction of the surf down Nantucket way, where he also sails during the summers, he exempted all twelve hours of finals. But a V-1 enlistment which matured into "active duty(?)" with V-12 in the summer of '43 didn't prove as strong a bait. In March of '44 the fly-boy complex and thoughts of F6F took over, and Pete headed for the Navy's own "blue yonder," with the V-5 training program. He's as hesitant as all flyers to talk of the rigors of the ITO (Iowa, Texas, and Oklahoma Theater) but the facts stand; he was commissioned and then discharged in March of '46 and he returned to Cornell that fall.

Versatile, as a description of this guy Sawyer, would appear to be an understatement. Along the line of honorary societies, Pete spends every other Tuesday night in the Sphinx Head Tomb, while the meeting and greeting of Red Key gave him a chance to chat with visiting teams during the '46-47 season. Athletic honors of the shortish Mr. Sawyer stem from his stellar performance at outside right for the varsity soccer team, a performance which, incidentally, sent him this year to the Olympic tryouts at Troy. But Pete's not a one sport

Pete

man, and while he plays at tennis, squash, and sailing, the bended knee and vorlage sport, skiing, is his other forte.

As for the Sibley School, Pete tells us, "I feel that the two best courses that I've taken in Sibley are Industrial Engineering and Marketing, and I plan to enter the field of industrial organization upon graduating. It's really disappointing, though, after groping so long to find my 'milieu propre', to be barred from taking some courses in this field now, just because I chose ME rather than AEME five years ago."

Trimp

Robert L. Trimpi, ME

Although his father was a Cornellian, C.E. '10, and his brother was enrolled in the same school, Bob started his college career at Stanford University in 1941. When war was declared he left school to work in war construction as a chief of party and field engineer until entering Cornell in the fall of 1942. A year later, after having sampled the V-12 program as a Marine trainee, "Trimp" transferred to the Army Air Forces. Here he spent the rest of the war with his six foot frame jammed into the tail-gunner's compartment of an 8th Air Force B-17.

Bob has always been very active in sports. After sustaining an injury in a scrimmage at Stanford, which prohibited further participation in football, he turned his attention to soccer. He played on the frosh soccer as well as the J.V. basketball team his first year here at Cornell. Since then he has been with the varsity soccer team as a center half-back for three years, with time out for army service; and in 1946 and '47 he was captain of the soccer squad. His high caliber of play was recognized by his being chosen for the North-South All Star soccer game in 1946 and the New York-New England All Star game this last fall.

Phi Kappa Sigma fraternity claims "Trimp" as a member. In his junior year he was elected to

(*Concluded on page* 32)

Cornell Society of Engineers

107 EAST 48TH STREET 1947-1948 NEW YORK 17, N. Y.

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GEORGE C. BRAINARD, *Vice-President* .....1200 Babbitt Rd., Cleveland, Ohio

LINTON HART, *Vice-President* .....418 New Center Bldg., Detroit 2, Mich.

"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students and to establish a closer relationship between the college and the alumni."

Carl F. Ostergren

How Professional Are Engineers?

I haven't looked up any of the definitions of "a profession" recently, but over the years I have understood that a dispassionate approach to the problems of the particular field is a key to identifying a professional man.

Since assuming my present assignment with the Cornell Society of Engineers I have had occasion to talk with more men engaged in various branches of engineering than I customarily do. A great deal of inspiration and respect for their ability and devotion to the requirements of their work has been my conclusion.

Yet I have a certain degree of difficulty in reconciling the attitude of some engineers to their own professional problems with their expressed opinions in more general areas of citizenship.

As an instance, several men, outstanding in their lines, deplore the much-belated efforts of the New York City administration to make a real advance in its transportation question. As a layman, and only a straphanger all my life, it seems to me that such a program should meet with the support of engineers. I am not so much of an optimist as to think that the speed of a New York transportation plan will interfere too much with the prices and scarcities with which these engineers are so much, and I suppose naturally, concerned.

The basic problem of the relation of the United States with the United Nations and with the Western European countries is clearly a matter in which experienced engineers should be interested and willing to think out conclusions. Reconstruction of productive capacity, industrial and agricultural, in the countries whose economy has been seriously impaired is a striking engineering, as well as a political, problem. Most of us, I would hope, are agreed that, while we should not try to enforce our political ideas on the countries we are setting out to assist, still we should try to see that most of our financial help will be wisely directed. Engineers should form opinions in this field.

Most of us, I believe, will agree in extending a word of support to Secretary Marshall. To many of us, at least, he seems to address himself to his very difficult questions as an engineer, with not only great ability, but with a keen sense of the world problems and a determination to make progress toward their solution.

His seems to be a professional approach in the basic meaning of one who puts the pursuit of truth above personal or political advantage.

CARL F. OSTERGREN

Alumni News

C. Reeve Vanneman, C.E. '03, is serving on three committees of Rotary International this year. He is chairman of the North American transportation committee for the 1948 convention in Rio de Janeiro next May 16-20, chairman of the magazine committee which publishes The Rotarian, and an ex-officio member of the 1948 convention committee. A consulting engineer on public utilities, Vanneman is a past president of the Cornell Alumni Corporation and the Cornell Society of Engineers.

James W. Parker, M.E. '08, president and general manager of the Detroit Edison Co., Detroit, Mich., and recently appointed chairman of a seven-man board of industrial consultants to the U. S. Atomic Energy Commission, was selected for the October 7 broadcast of the United Press radio feature, "Names in the News." Parker was formerly an Alumni Trustee of the University.

Creed W. Fulton, M.E. '09, is vice-president of The Samuel J. Creswell Iron Works in Philadelphia, Pa. The company manufactures architectural and structural iron and steel. Fulton had been assistant to the president and industrial engineer at American Pulley Co. in Philadelphia. He is the executive vice-president of the Cornell Society of Engineers.

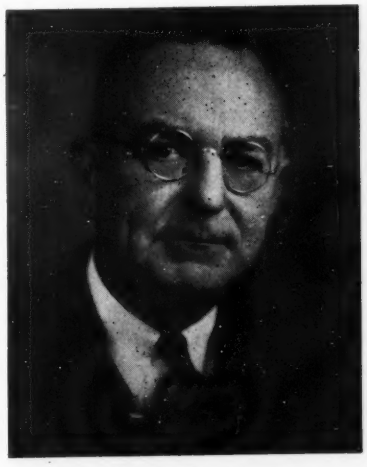
Major General C. P. Gross, M.E. '10, has retired as chairman of the New York City Board of Transportation. He took the post two years ago after many years in the Corps of Engineers, USA. During the last war, General Gross was chief of transportation for the Army Service Forces in Washington, D. C.

Clayton S. Coggeshall, M.E. '11, has been appointed manager of sales of the Turbine and Gear Divisions of General Electric's Apparatus Department. Manager of the former Turbine Sales Division of General Electric since 1938, he has been associated with turbine sales work since 1915.

Alan F. Williams, C.E. '15, formerly a lieutenant commander, USNR, is transportation engineer for the California Public Utilities Commisson in Los Angeles.

George C. Ruby, M.E. '15, has resigned as sales manager for George F. Motter's Sons and is again actively associated with the Home Insulation Co. of Central Pennsylvania and Dealers Building Materials Co., both of York, Pa., which he organized in 1929 and 1945, respectively.

Curtis S. Crafts, M.E. '16, is vice-president and chief engineer of Goss Printing Press Co., Chicago, Ill.



C. Reeve Vanneman

Daniel M. Coppin, C.E. '26, has been elected secretary-treasurer of the Fisher-DeVore Construction Co., general contractors of Cincinnati, Ohio. He has been a director and vice-president of the firm.

A. Churchill Blackman, M.E. '29, was appointed last June as chief of the Division of Industrial Safety, California Department of Industrial Relations, by Governor Earl Warren. For more than fifteen years he had been district engineer for the Liberty Mutual Insurance Co. in Charlotte, N. C.

James T. Lewis, M.E. '27, has been granted the first welderies classification award of $3,200 in the design-for-progress program sponsored by the Lincoln Arc Welding Foundation of Cleveland, Ohio. The prize was awarded for a paper discussing a commercial welder's facilities, administrative organizaton, and routines in day-to-day operations. Lewis is president and general manager of the Lewis Welding and Engineering Corp. of Bedford, Ohio, which he organized in 1938.

Paul S. Symonds, Ph.D. '43, has assumed an assistant professorship in electrical engineering at Brown University, where he will devote a portion of his time to teaching in the graduate division of applied mathematics. He has been a physicist at the Naval Research Laboratory.

Walter W. Merkel, Jr., B.S. in E.E. '47, is relay engineer for the Pennsylvania Electric Co.

Deceased

John F. Booraem, M.E. (E.E.) '91, retired manufacturer and consulting engineer on October 9, 1947. He was an engineer and a director of the American Brick and Tile Co.

Charles Burns, M.E. '08, of Hartford, Conn., on October 6, 1947. He had formerly been with Underwood-Elliot-Fisher Co. Burns had established the Burns Trophy, to be awarded annually to the outstanding member of Pershing Rifles, in honor of his son, the late Charles Burns, Jr. '40, former captain of Pershing Rifles.

William H. Phillips, Jr., M.E. '12, vice-president of Molybdenum Corp. of America on October 10, 1947. Phillips was a past president of the Cornell Club of Pittsburgh, and during the last war, he was advisor to the civilian steel supply division of the War Production Board.

News of the College

UNH Chooses Adams

Dr. Arthur S. Adams, provost of Cornell University, has been elected president of the University of New Hampshire, it has been announced by the University of New Hampshire Board of Trustees. He succeeds Dr. Harold W. Stoke. The announcement came after Dr. Adams had tendered his resignation to the Cornell Board of Trustees at their last meeting. He will conclude his duties at Cornell with the end of the current academic year.

Dr. Adams became provost at Cornell in January, 1946, and in this capacity has been chief administrative officer under President Day. At Cornell, previous to 1946, he had served as professor of mechanics, assistant dean of the College of Engineering, and director of the University's engineering, science and management war training program until called to active duty by the Navy in November, 1941.

It was in 1944, while he was serving as general administrator of the Navy's vast training program, that Dr. Adams was elected provost. He received the Legion of Merit for his work in this activity and in the establishment of the postwar Naval Reserve Officers Training Corps. Dr. Adams was released from active duty in November, 1945, with the rank of captain.

After graduation from the Naval Academy in 1918 and subsequent retirement in 1921, he taught in Denver public schools for four years. He received an M.A. in physics at the University of California, Berkeley, in 1926, and a Sc. D. in physics and metallurgy at the Colorado School of Mines the following year. Dr. Adams was appointed an instructor in metallurgy at that institution upon receipt of his doctorate and became successively assistant associate, and full professor and assistant to the president, until 1940 when he came to Cornell University.

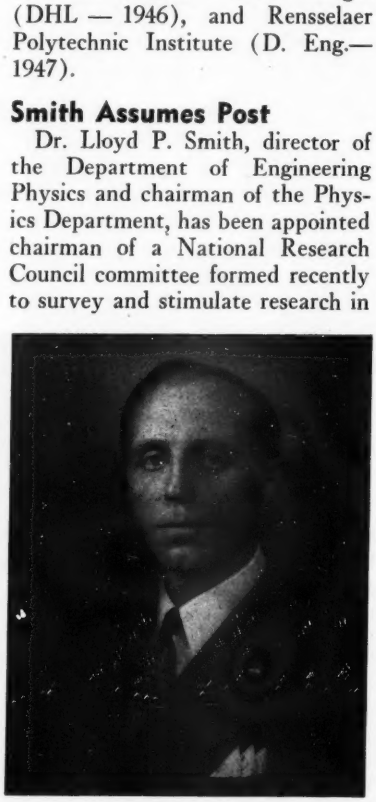
At Cornell, in addition to his general administrative duties, he has headed a committee on housing established to provide accommodations for a student body increased by 40 per cent over prewar enrollment.

He is chairman of the American Council on Education's committee on housing and a member of the delegatory committee of the Engineers' Council for Professional Development for Region II of the Committee on Engineering Schools. He is a member of the ASME, ASEE, Tau Beta Pi, AAAS, AAUP, Sigma Xi, and Phi Kappa Phi.

Six institutions have honored Dr. Adams with honorary degrees—Muhlenberg College (LL.D. — 1944), Union College (Sc. D.—1944), University of the South (DCL—1945), Stevens Institute of Technology (D. Eng.—1945), Hobart and William Smith Colleges (DHL — 1946), and Rensselaer Polytechnic Institute (D. Eng.—1947).

Smith Assumes Post

Dr. Lloyd P. Smith, director of the Department of Engineering Physics and chairman of the Physics Department, has been appointed chairman of a National Research Council committee formed recently to survey and stimulate research in



Lloyd P. Smith

phenomena connected with matter in the solid state. The committee is composed of leading figures in physics, chemistry, metallurgy, mineralogy, ceramics, and related fields. The group will work closely with the Office of Naval Research and the Research and Development Board.

Elected IRE Chairman

Dr. Charles R. Burrows, director of the School of Electrical Engineering, has been elected chairman of the technical program committee for this year's convention of the Institute of Radio Engineers, to be held in New York March 21-25. Last year's convention attracted 12,000 members, who took part in 24 sessions and heard 124 technical papers.

Dr. Burrows has appointed sixteen committee members, including Dr. Edwin W. Hamlin and True McLean, professors of Electrical Engineering at Cornell.

Buffalo Lab Cited

The Cornell Aeronautical Laboratory at Buffalo has been cited by the Armed Forces Special Weapons Project for the successful demonstration of underwater television in recent tests at Bikini Atoll. Rear Admiral W. S. Parsons, deputy chief of the project, in a letter to Karl D. Swartzel, head of the department of physics at the laboratory, called the demonstration "a real contribution to science."

The tests were carried out by a Cornell party during the scientific resurvey of the atoll, where two experimental atomic bombs were exploded. The remote-control television cameras, adapted from those used by the Navy to scan instruments in pilotless planes, enabled observers to see fish swimming around the deck of a submarine 160 feet below the surface.

Bailey Hall Show

Bailey Hall was transformed into a television studio on December 17, when a demonstration of television operations from actual televising to theater-size reproduction was given under the auspices of the

(*More news on page* 32)

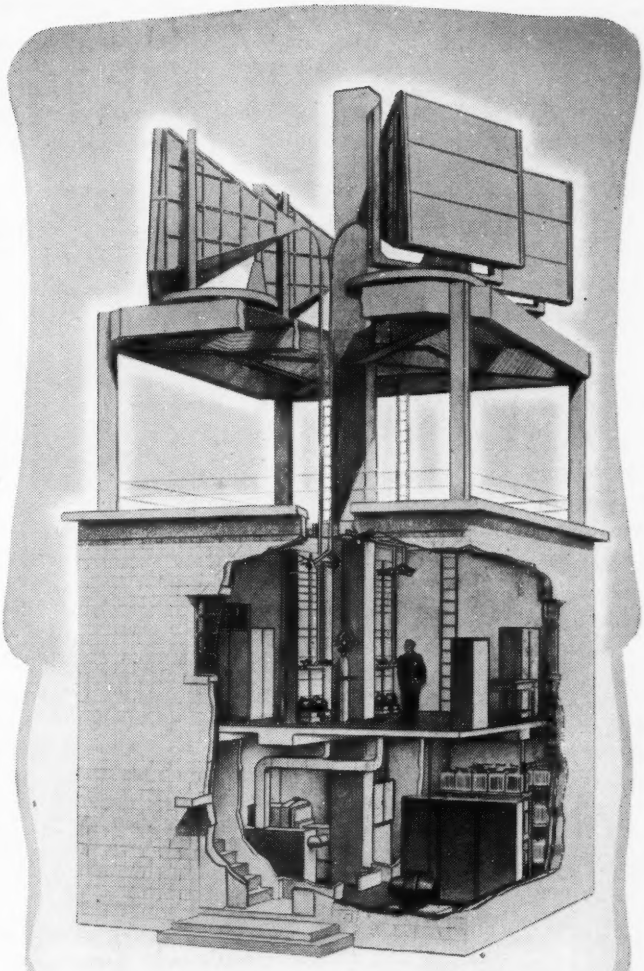
TELEPHONY'S SEVEN LEAGUE BOOTS...

THIS tower reflects great strides in communications. It's one of the seven new radio relay towers that link New York City and Boston.

This new path for Long Distance communication uses microwaves . . . free from static and most man-made interference. But, because microwaves shoot off into space instead of hugging the earth's curve, we've had to build relay stations within line of sight to guide the waves between the two cities. Atop each tower, metal lenses gather these waves and, after amplification, relay them to the next tower. The lenses focus and direct the radio waves like a searchlight beam.

This new system for transmitting Long Distance telephone calls, radio and television programs is but one phase in the Bell System's program for improving this country's communication service; a never ending program of growth and development in which many telephone engineers will participate, and whose careers will develop with it. *There's a future in telephony.*

BELL TELEPHONE SYSTEM



A cut-away view of a typical radio relay station. Emergency power equipment and storage batteries are on the first floor, radio equipment on the second floor, and the special microwave antennas which receive and beam the communication signals are on the roof.

Out of Phase

By HERBERT F. SPIRER, EP '51

Sights And Smells, Or Explorations On The Arts Campus By Notable Cornell Engineers

Since the recent stab-in-the-back by that curmudgeon of the cheap, obstreperous throw-aways, the anemic Widow, we have had a cautious eye peeled for possible eyesores on the Arts campus. The Widow and its scurrilous newshawks have seen fit to malign Lincoln's clock, presumably in the interests of more beauty about our campus.

Our search was hardly under way before letters began to flood the office. A few of these informative complaints and critical praises are reproduced for your information...

Sanitary Engineer, '90, Discovers Goldwin Smith

Der Konnell Engneer;

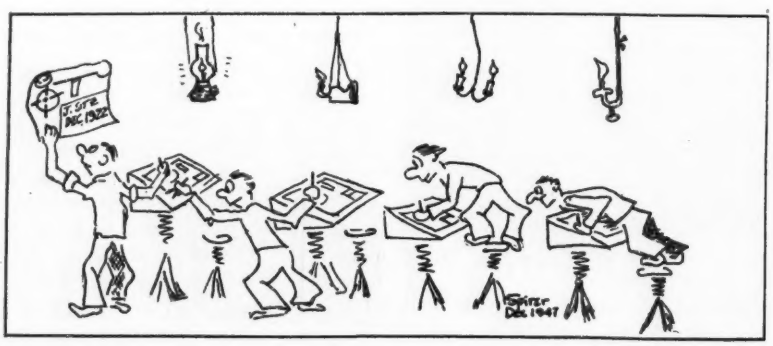
As I am previously long time graduate Conell Sibley School from engineering, namely, 1890, sanitary engineer, i am looking forward, not backwards to sending my kiddies, now twins age 47, to an Arts colledge they should learn proper English and philosophy yet, not get to bē one sided enginear like old man, me.

So wot happens when I am draggin my incalcitranting legacies up to dis place? Yet they go into Goldwin Smith, I have led for them a sheltered life these 47 years for what? For they should be shocked out of their skins yet, they see the awful sights in the lobby dis great hall. In dis lobby is basement, such a hobble basement I have never seen in mine 45 years as sanitary engineer, first class. Dis basement, dis catacomb with gas lights, is full of stark raving nude stachoos, naked men, women and completely unclothed female wolves, and ugly animals and humans with their hands yet even arms, sometimes legs all ge-broken off.

The kiddies are screaming, I should clutch them to my breast protect them yet from such a disgusting place. This hobble thing must be removed or I am making legal steps cancel my subscription to Cornell Era and Sunday Observer.

(signed) Rasputin J. Z. Sitzfleisch

P.S.—The kiddies, bless their hots, are now safe reading books at decent school yet, a smoll place in South Philadelphia, by name yet University from Pennsylvania.



Aerial Reconnaissance by Air-Minded Alumnus

Dear Engineer:

While flying my new high speed plane, commonly known as the "flying beer bottle," a considerable improvement over my earlier "flying cider jug," I noticed something unusual as I passed the Cornell Campus.

Such an atrocious smell arose from a certain portion of the campus, that my nostrils were highly offended. Upon circling closely and adeptly using my new sub-roto dihedral heliocopting shimmying flappers, I was able to trace the source of the offense.

It turned out to be a small winding stream which passed Sage at one end and the Straight at the other. At the beginning of the stream I discovered that several thousand copies of an obscure Cornell publication, the Widow, had been dumped carelessly into the formerly clear waters. Surely there must be local laws concerning the pollution of public waters.

This will, I believe, account for the odor coming from that once delightful country brook beside which Adolph Menjfliesch and I used to while away our undergraduate hours, panning gold.

Aeronautically yours,

(signed) Leroy R. Grumfleisch, '16

Anybody Speak French?

Mon Cher Engineur;

Ou est mon zlide rule?

(signed) Ferdinand de Lesseps, '76

"Our American concept of radio is that it is of the people and for the people."

Freedom to LISTEN – Freedom to LOOK

As the world grows smaller, the question of international communications and world understanding grows larger. The most important phase of this problem is *Freedom to Listen* and *Freedom to Look*—for all peoples of the world.

Radio, by its very nature, is a medium of mass communication; it is a carrier of intelligence. It delivers ideas with an impact that is powerful . . . Its essence is freedom—liberty of thought and of speech.

Radio should make a prisoner of no man and it should make no man its slave. No one should be forced to listen and no one compelled to refrain from listening. Always and everywhere, it should be the prerogative of every listener to turn his receiver on or off, of his own free will.

The principle of *Freedom to Listen* should be established for all peoples without restriction or fear. This is as important as *Freedom of Speech* and *Freedom of the Press.*

Television is on the way and moving steadily forward. Television fires the imagination, and the day is foreseen when we shall look around the earth from city to city, and nation to nation, as easily as we now listen to global broadcasts. Therefore, *Freedom to Look* is as important as *Freedom to Listen,* for the combination of these will be the radio of the future.

The "Voice of Peace" must speak around this planet and be heard by all people everywhere, no matter what their race, or creed, or political philosophies.*

David Sarnoff

President and Chairman of the Board,
Radio Corporation of America.

**Excerpts from an address before the United States National Commission for UNESCO.*

RCA **RADIO CORPORATION of AMERICA**

FREEDOM IS EVERYBODY'S BUSINESS

LUFKIN "Peerless" Chrome Clad Steel Tapes

Rough, tough measuring work can't hurt the Lufkin "Peerless" Chrome Clad Steel Tape. Jet black markings are always easy to read. Sturdy steel line is covered with satin smooth chrome that resists rust and will not crack, chip, or peel. For free catalog write THE LUFKIN RULE CO., SAGINAW, MICH., New York City.

LUFKIN
FOR ACCURACY

FEBRUARY'S THE MONTH FOR—

JUNIOR WEEK — Gifts and souvenirs for fair Junior Week guests.

ST. VALENTINE'S DAY — Greeting cards and appropriate gifts.

WINTER SPORTS CARNIVAL — Skis, skates and all equipment.

SPRING TERM OPENING — Books and supplies for all courses.

BOOK BUYING MONTH — Bring in your used texts and turn them in to cash.

◇

A SHORT MONTH — A BUSY MONTH

◇

THE CORNELL CO-OP

BARNES HALL — ON THE CAMPUS

Use the **CORNELL UNIVERSITY PLACEMENT SERVICE**

Administration Building, Ithaca
John L. Munschauer '40, Director

New York Office, 107 E. 48th St.
Paul O. Reyneau '13, Manager

Tacoma Bridge

(*Continued from page* 9)

nolds Number has little influence in this particular case. Tests of models of the same section at different scales and at high wind velocities support this conclusion.

Section models (Fig. 2) are short sections of the suspended structure with the elastic properties of the entire bridge reproduced by springs. They are much less expensive and quicker to construct. This makes it possible to test numerous variations in form of construction.

Test Program

The objects of the test program were to:

1. Establish correlation between the scale model and the prototype, and between the section and full length scale models.
2. Insofar as possible, ascertain the causes of the vibrations.
3. Discover a cross-section which would be least responsive to aerodynamic forces.

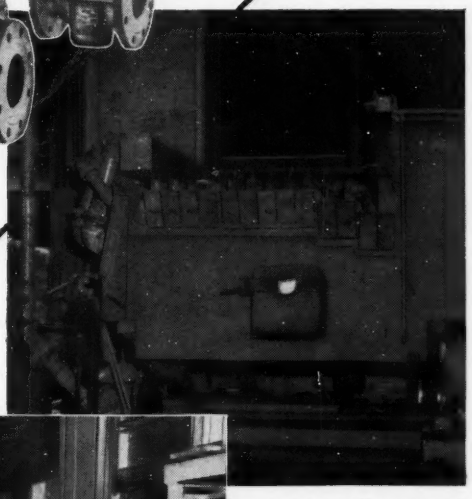
Three complete full scale models were constructed and tested. The first was a model of the original bridge, the primary purpose being to establish the validity of the entire test program. Good correlation was established, the results in the wind tunnel corresponding closely to the observations on the original bridge. The results of these tests are shown by Fig. 1. Attention is called to the following:

1. Five vertical modes of vibration are shown, each reaching maximum amplitudes at a given wind velocity. For each of these diffferent points of maximum amplitude the ratio v/n (velocity over frequency) is approximately constant of 2.0.
2. In any vertical mode of vibration as the wind velocity either increases or decreases, the motion dies out.
3. The maximum double amplitude of vertical vibration on the model was 0.5 ins. corresponding to 25 inches on the prototype. The maximum observed on the original bridge was 60 inches. In the laboratory careful timing with an uniform velocity was required to secure these maximum amplitudes on the model. In the original bridge they occurred with natural winds. This leads to the conclusion that the damping of the bridge was less than that of the model.
4. There were two appearances of single-noded torsional vibrations. The response curve in the first appearance was a closed loop similar to those for the vertical vibrations. In the second appearance, with increasing wind velocity the amplitudes increased without any upper

(*Continued on page* 28)

GAS.. PRODUCTION-LINE FUEL

Homestead Lever-Seald Valve—for handling fluids at high pressures and temperatures—one of the multitude of Homestead Valves for all types of applications.



Gas-fired "SKLENAR" Furnace for high-speed melting of ferrous metals.

Sectional Gas-fired core-drying oven.

for FOUNDRY MODERNIZATION

Foundry modernization is a continuing project at Homestead Valve Manufacturing Company, Inc., Coraopolis, Pa., because Homestead engineers have since 1892 kept their sights set on modern productioneering equipment and methods.

And, in their research, these engineers have investigated fuels and combustion techniques as they apply to foundry practice. As a result the productive flames of GAS are increasingly important and more extensively used in Homestead's production lines.

Modern Gas-fired Foundry Equipment, such as the "SKLENAR" furnaces for ferrous metal-melting, utilize the special characteristics of GAS—flexibility, controllability, speed. This saves equipment space, melting time, and lining maintenance. Operating at 2700° F. these furnaces have a capacity of one ton heat per hour, and 160 heats per lining—evidence that modern Gas Equipment is really productioneering equipment.

But this is not the only GAS application in the manufacture of Homestead valves. Core ovens, annealing furnaces, and non-ferrous crucible furnaces are all heated by the productive flames of GAS. In modern foundry practice, GAS is the logical fuel for all heating and heat-treating operations.

AMERICAN GAS ASSOCIATION
420 LEXINGTON AVENUE, NEW YORK 17, N. Y.

Tacoma Bridge

(*Continued from page 26*)

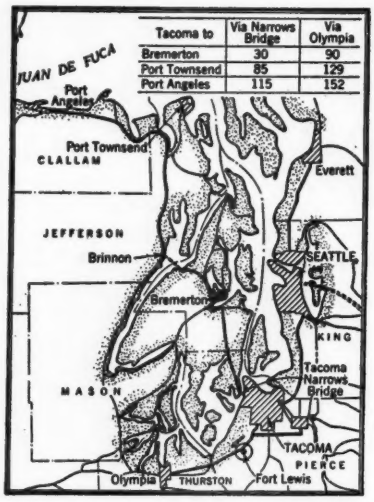
limit insofar as could be determined. Further increases of the wind velocities would have wrecked the model.

5. These two forms of curves have been termed "non-catastrophic" and catastrophic respectively. The amplitudes in the first case may be sufficient to be objectionable but they do not produce dangerous stresses. In the second case the amplitudes are such as to result in the failure of the structure.

Further tests on section models of plate girder sections developed additional data as follows:

1. For geometrically proportional sections, the critical velocities, Vc/nb, are the same for all vertical modes.

2. The response of the section is affected by the h/b ratio (h depth of girder and b — distance c. to c. girders) with increases in this ratio, vertical vibrations may become catastrophic. With decreases, the section approaches a "flat plate" and the vibrations become binary,



Site for the new bridge over Puget Sound from the mainland to Olympic Penisula is the same as for the original structure.

—Courtesy Civil Engineering

a combination of vertical and torsion, i.e., torsion about a center of rotation removed from the center of the section. In general, the center of rotation is not a fixed point but shifts.

Upon completion of the tests on the model of the original bridge, a model was constructed of a conventional deck truss structure, the truss depth (prototype) being 33 ft. and the spacing 60 ft. The tests indicated that this section was stable under all conitions except that binary vibrations developed at critical velocities ranging from 50 mph at a vertical angle of 8° upward to 80 mph at 2° upward. No vertical vibrations could be developed by any combination of velocity and angle of attack.

While these tests represented a great improvement over the original bridge, the results were not considered satisfactory. Therefore attention was turned to the possibility of finding a section less responsive to wind. In all, tests were made on 76 different cross-sections, including minor variants. The most satisfactory was a cross-section represented by Fig. 3 (b) where slots are introduced into the roadway. In the actual design, these slots will be formed by open grating between the concrete slabs.

(*Continued on page 30*)

MACWHYTE WIRE ROPE

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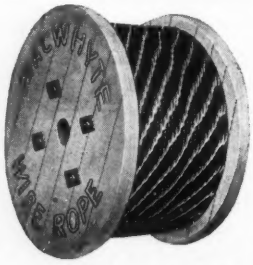
KENOSHA, WISCONSIN

New York — Pittsburgh — Chicago — Minneapolis — Forth Worth — Portland — Seattle — San Francisco — Los Angeles — Distributors throughout the U.S.A. and other countries.

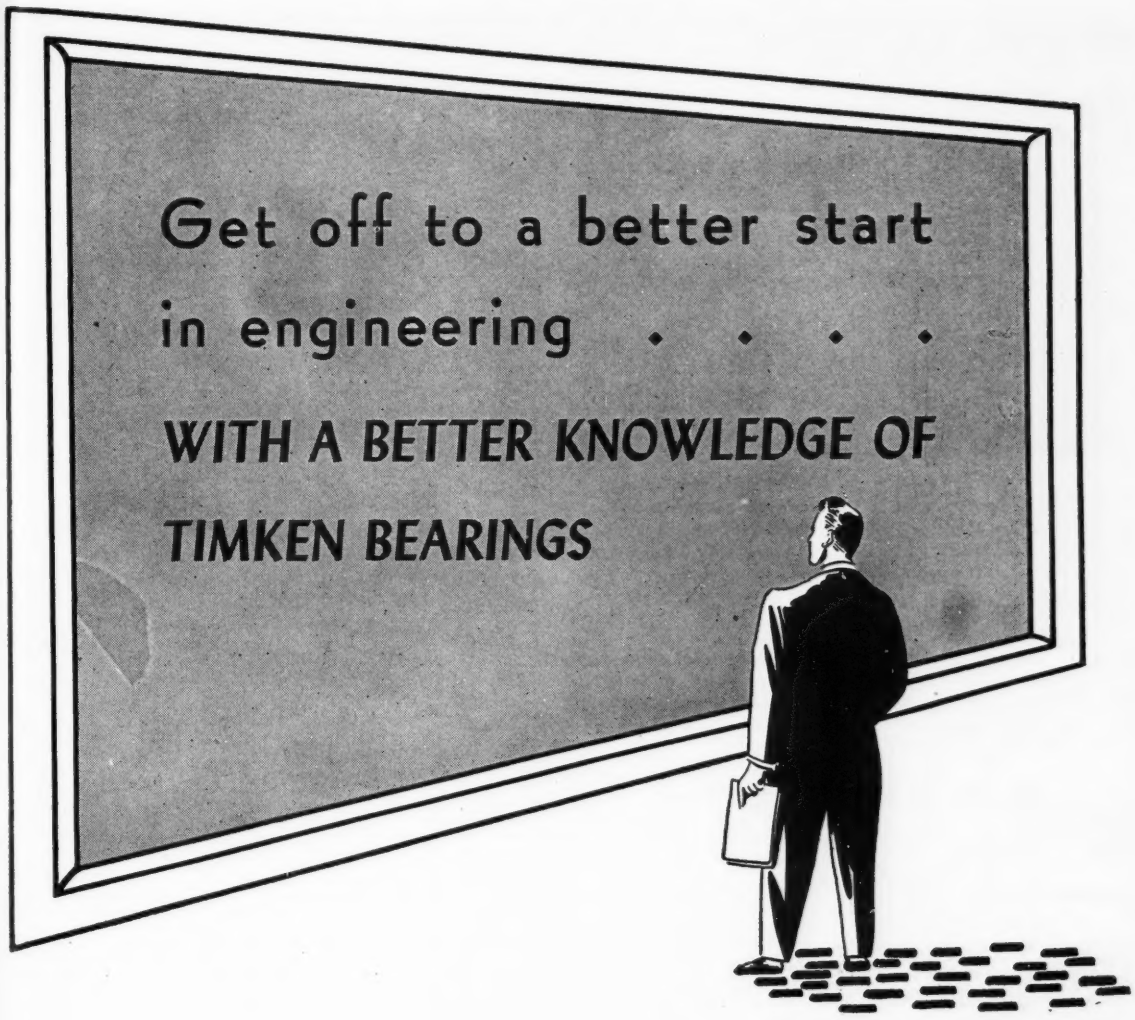


Manufacturers of Macwhyte PREformed and non-Preformed Internally Lubricated Wire Ropes . . . Monarch Whyte Strand . . . Elevator Rope . . . Stainless Steel Wire Rope . . . Monel Metal Wire Rope . . . Galvanized Wire Rope . . . Spring-Lay Wire Rope . . . Braided Wire Rope Slings . . . "Hi-Fatigue" Aircraft Cables . . . "Safe-Lock Cable Terminals, Assemblies, and Tie Rods.

Jessel S. Whyte, Pres. ME '13 R. B. Whyte, V.P. ME '13
George S. Wilder AB '38 John F. Bennett CE '27

Ball de Mi-Carême

featuring



A good start is half the race. The more you know when you graduate, the better your opportunity for success.

Your professors have your best interests at heart, but what you learn outside the classroom will be a plus advantage of great value when you toe the mark for the start of your career.

Take bearings for example. No form of mechanical equipment with rotating parts can operate without them. By acquiring now a thorough knowledge of Timken Tapered Roller Bearings—their design, application and possibilities—you will be in position to meet and beat any bearing problem you ever may encounter.

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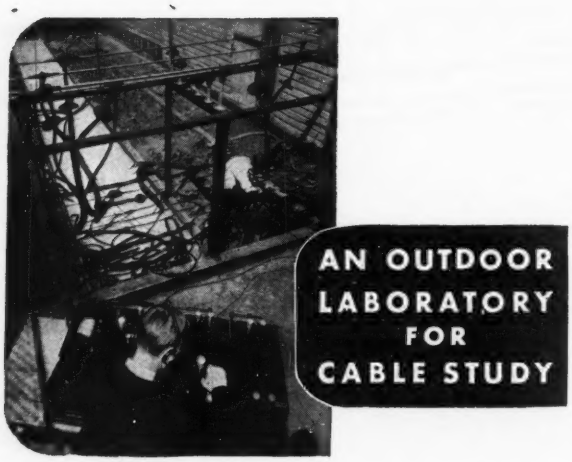
Our engineers will help you to become a bearing specialist. Write us today and tell us what course you are studying. The Timken Roller Bearing Company, Canton 6, Ohio.



Nothing is guessed at, nothing is taken for granted by the engineers in charge of Okonite's cable proving ground. Buried in various types of chemically different and highly corrosive earth, pulled into conduit or installed overhead, electrical cables are tested under controlled conditions of temperature, voltage and loading conditions duplicating those of actual operation.

In use since 1936, carefully-recorded tests made in this "outdoor laboratory" have disclosed valuable trends. As facts accumulate, Okonite engineers apply their findings to the improvement of their electrical wires and cables. The Okonite Company, Passaic, N. J.

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DIAL 2014 ITHACA, NEW YORK

MAXWELL T. KENDALL '36, *Headmaster*

Tacoma Bridge

(*Concluded from page* 28)

With this cross-section, the only vibrations under wind had a double amplitude of 1° at a wind velocity of 36 mph with an upward angle of attack of 6°. These results were confirmed by tests on the full model. The difference in the wind flow as indicated by the smoke in the two sections furnishes an explanation of the superior behavior of the plotted section. In (a) there is a large area of reduced pressure which in (b) is relieved by the flow through the slots.

During the experimental studies, an Advisory Board on the Investigation of Suspension Bridges, composed of several engineers experienced in suspension bridge design was formed under the auspices of the Public Roads Administration. As part of the investigation sponsored by this Board, an extended mathematical investigation of bridge vibrations was made by Dr. Freidrich Bleich. Perhaps his most important finding was that the critical velocity of binary vibrations could be greatly increased by increasing, materially, the torsional frequency and leaving the vertical frequency unchanged. This can be accomplished by introducing a lateral system in the planes of both the top and bottom chords. This resulted in two methods of insuring would occur. By using the two lateral systems, the critical velocity would be raised to above 100 mph even with the improbable angle of attack of 8°. By introducing the slots in the roadway, no vibrations of appreciable magnitude are probable. To be absolutely safe, both measures have been adopted in the final design.

Acknowledgements

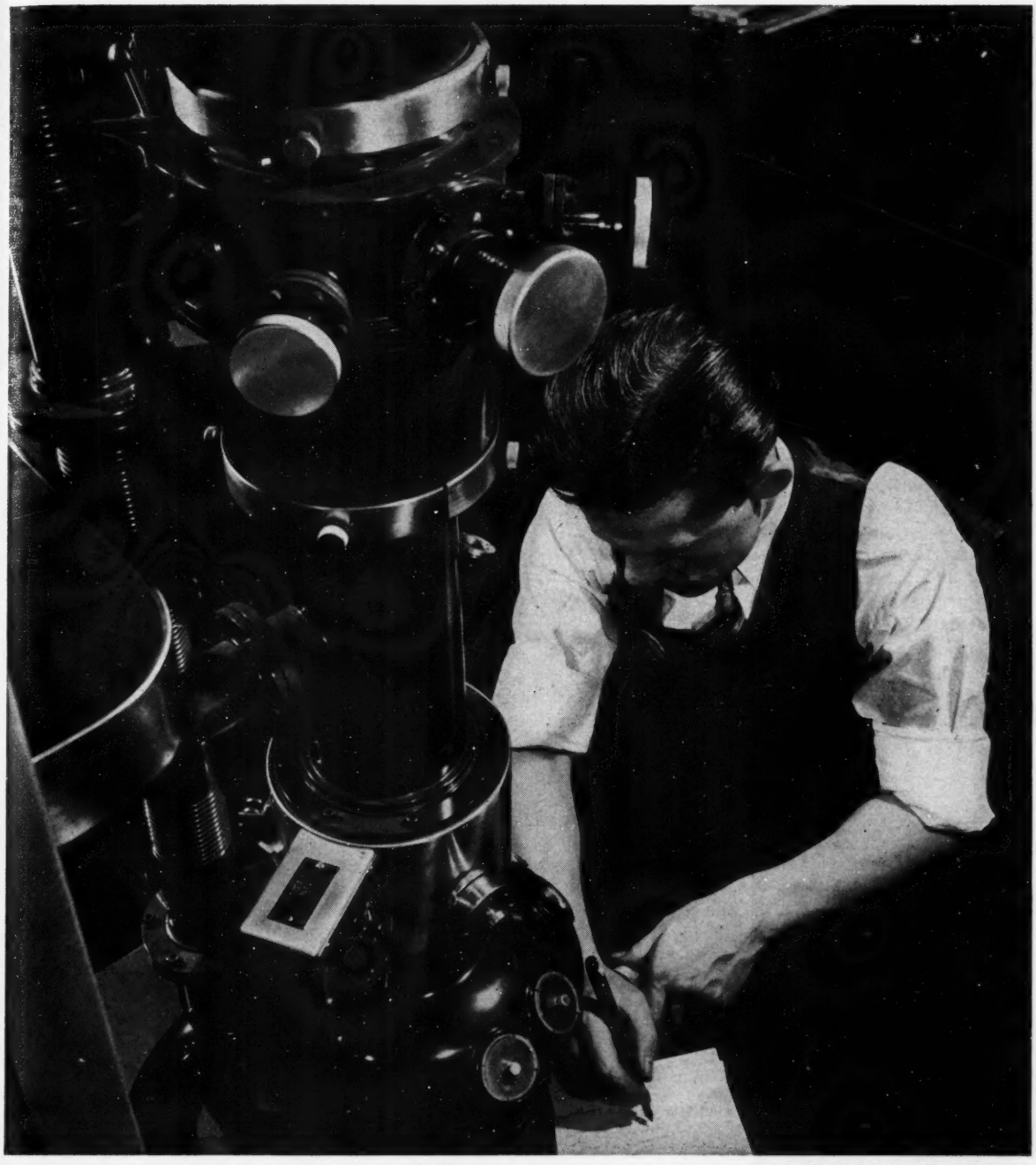
The Tacoma Narrows Bridge is being reconstructed by the Washington Toll Bridge Authority. The redesign is directed by a Board of Consulting Engineers composed of Chas. E. Andrew, John I. Parcel and the writer. Dr. Theodor von Karman has served as Consulting Aerodynamicist. Dexter R. Smith has been Engineer of Design. The investigation at the University of Washington has been conducted cooperatively by the Washington Toll Bridge Authority and the Public Roads Administration. It has been directed by Prof. F. B. Farquarhson of the University, assisted by Mr. George S. Vincent, representing the Public Roads Administration. Dr. Louis G. Dunn was in charge of the research at the California Institute of Technology. Mr. E. F. Kelley is chairman of the Advisory Board on the Investigation of Suspension Bridges.

Norway's White Coal

(*Continued from page* 11)

dry season of the year. Since Norwegians have little usable land, they do not flood more of it than is absolutely necessary. Therefore, they conserve more of their soil by eliminating this erosion hazard. Geologically, the rock is mostly of granitic origin. It contains great quantities of quartzite, and it is interesting to note that gunniting or otherwise lining tunnels is almost unknown because of the non-porous properties of the rock.

(*Concluded on page* 32)



Research is Progress . . . and Progress means improved Product Quality!

This petroleum company fully recognizes the value of research—and the kind of men needed to do this important work. They deem it their responsibility to help maintain American leadership in the field of petroleum research and in the production of fine fuels, lubricants and chemical products derived from petroleum.

Over 2000 scientists and technicians are engaged in Esso research work... and their ranks are still increasing!

Esso Laboratories are the largest petroleum research laboratories in the United States—and work to enlarge them is almost complete.

Unending, intensive research of this nature always assures high quality and dependability in Esso Products... at sea, in the air and on the ground.

Esso

STANDARD OIL COMPANY
OF NEW JERSEY

Unending Research Work Assures The High Quality Of All Esso Products

Norway's White Coal

(*Concluded from page* 30)

There are, however, some dams in Norway similar to those built in the United States. These are located in the Glommen River and are high head plants. Water is taken from an intake in the river, through a tunnel to a steep pipe line and down to the power station. The head is variable. Some have heads up to 3000 feet. A conservative estimate of the potential power of all Norwegian rivers is 9,000,000 kilowatts or 80 billion kilowatt hours a year of which fifteen percent has been utilized up to now. If all the stations were working at maximum efficiency on a grid system, 100 to 110 billion kilowatt hours might some day be realized. This is constant power; that is, power for 12 months of the year.

New and proposed uses for the electrical power developed by Norway's white coal include plans for the complete electrification of Norwegian railways, cities, and homes. Plans are also being made for the modernization of Norway's great fishing industry, using electricity to deep freeze those fish which are to be exported.

John D. Saunders, CE

(*Concluded from page* 19)

Delta Theta, elected him president.

As far as John's post-graduation plans are concerned, he wants always to be connected with field construction. His interest stems from the work of his father, who was a well-known New York contractor, and of his brother, who is superintendent for another New York construction company.

Robert L. Trimpi, ME

(*Concluded from page* 19)

Quill and Dagger and Red Key. By virtue of having been on the dean's list every term, Bob is also a member of Tau Beta Pi, honorary engineering society, verifying his aptitudes in engineering.

Although most of "Trimp's" experience, which began as a six year old on his father's construction jobs and since has continued in summer employment, lies in the field of civil engineering, aeronautical engineering is his main interest. He is taking all his electives in the graduate school and hopes to receive a Masters in Aeronautical Engineering after one year of post graduate study.

College News

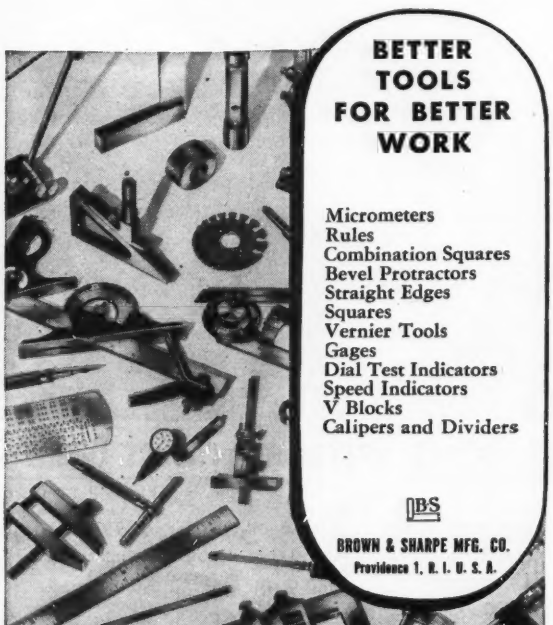
(*Continued from page* 22)

Cornell chapter of Sigma Xi and the Schiff Lecture Foundation. E. W. Engstrom, vice president in charge of research for the Radio Corporation of America and leader in television development, spoke and explained the operation of the camera and projection equipment, which was supplied by RCA Laboratories and RCA Victor Division of Radio Corporation of America.

SAE Meeting

(*More news on page* 34)

On December 16 Winfield D. Gove led a discussion on "Aircraft Engine Developments" at a meeting of the Syracuse Section of the Society of Automotive Engineers in Olin Hall. Mr. Gove, piston en-



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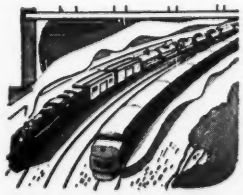
We're not so hot on POGO STICKS

Lots of people like to play jack rabbit. Still, as a way of going to work every morning, we don't see much of a future for Pogo Sticks. Not even *aluminum* Pogo Sticks.

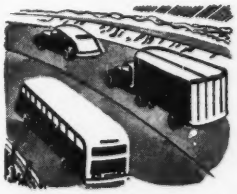
But mention any other means of locomotion or transportation and our aluminum "Imagineers" get a gleam in their eyes. After all, what is more logical than vehicles made of aluminum? Less weight to move. More payload.

We turned our imagination loose on that idea years ago . . . then engineered our thinking into trains, trucks, planes, ships. Alcoa's Development Division has a staff of "Imagineers" who think of nothing else but better ways to transport people, products, and materials by using aluminum. Actually, we have *four separate* staffs of transportation engineers, one each on railroads, highway vehicles, ships and aircraft.

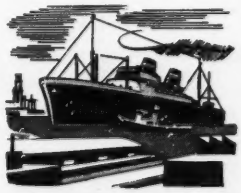
Whatever you do after college, you'll benefit from that. If you go into transportation, these Alcoa engineers will be working with you to cut costs, speed schedules, improve facilities. Or if you choose some field of production, they'll be helping to transport your materials and finished goods cheaper and faster. ALUMINUM COMPANY OF AMERICA, Gulf Building, Pittsburgh 19, Pennsylvania.



Passenger streamliners, refrigerator cars, hopper cars and tank cars built of Alcoa Aluminum are serving American railroads.



Alcoa Aluminum is finding more and more uses in buses, trucks and trailers. Yes, in passenger car manufacture, too.



Newest thing in shipbuilding is the aluminum superstructure, developed by Alcoa with marine architects and engineers.

Ever since Kitty Hawk, Alcoa has worked with the aircraft industry in developing better aluminum for better planes.

ALCOA FIRST IN ALUMINUM

IT'S GOOD BUSINESS TO DO BUSINESS WITH THERMOID

Why? Because Thermoid concentrates on a restricted line of products, related in manufacture and in use, and maintains those products at top quality level.

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Engineers depend on Thermoid to always furnish well made INDUSTRIAL BRAKE LININGS and FRICTION PRODUCTS, TRANSMISSION BELTING, LIGHT DUTY and MULTIPLE V-BELTS and DRIVES, CONVEYOR and ELEVATOR BELTING, WRAPPED and MOLDED HOSE.

If catalogs on any of these lines would be helpful in your studies, we'll be glad to furnish them.

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College News

(*Continued from page* 32)

gines development engineer for the Pratt & Whitney Aircraft Division of the United Aircraft Corporation, is generally credited with conducting the first power measurements of reciprocating engines in flight in 1925-1928.

Student Lounge

If proposed plans are carried out, students and faculty members of the Sibley School of Mechanical Engineering will in the near future be able to enjoy the benefits of a spacious lounge. Members of Kappa Tau Chi, with Professor Andrew S. Schultz as faculty adviser, are sponsoring the idea, feeling that the Sibley School needs a center in which students and faculty may relax, read, smoke, and hold formal or informal gatherings. It is expected that such a meeting place will do much to promote spirit in the school.

An unused room in the basement of Sibley Dome has been found sufficiently large and easy to convert, and the proponents of the plan believe that, with the help of student labor and alumni contributions, it can be made into a comfortable gathering place.

Appointments

Mechanical Engineering

Harry D. Conway has been appointed associate professor of mechanics in the School of Mechanical Engineering. A native of England, Mr. Conway received the B.S. in 1942 at the University of London; the Ph.D. (research) in 1945 and the M.A. in 1946 at Cambridge University. He was an evening lecturer in mathematics and strength of materials at Medway Senior Technical College in Gillingham, England in 1938-1939. From 1942 to 1945, he carried on research in the National Physical Laboratory at Eeddington, Middlesex, on creep of materials and fatigue at elevated temperatures, and elasticity problems in connection with gun design.

George B. Du Bois, who assumes the rank of associate professor of mechanical engineering, is a Cornell alumnus. He received the A.B. in 1927 and the M.E. here in 1929. Until 1931 he was employed by the Sperry Development Company and from then until 1936 he worked as project engineer for Lycoming Division of Aviation Manufacturing Company. Following this he worked wth Wright Aeronautical Corporation until he came to teach at Cornell.

Another Cornell alumnus is Edwin B. Watson, who has been appointed associate professor of mechanical engineering. He received the B.S. in 1939 at the University of Rochester, and the M.S. in Engineering at Cornell in 1943. He has served as instructor at Cornell in the College of Engineering, and in 1943 he was appointed assistant professor of engineering materials assigned to the Navy Diesel Training School.

Civil Engineering

Promoted from assistant to associate professor is Melville S. Priest, of the School of Civil Engineering. Mr. Priest received the B.S. in 1935

(*More news on page* 36)

PEOPLE DON'T STANDARDIZE ON "SUBSTITUTES"

For nearly 15 years, molybdenum high speed steels have *proved on their own merits* that they are *superior* steels. Long before World War II, during the war, and up to the present moment, these steels have done *more* work for *less* money.

Molybdenum high speed tool steels, for instance, are not only tougher, and do more work per job, but are consistently cheaper than 18-4-1. In addition, they are from 6% to 9% less dense, so more tools may be made from the same gross weight of steel.*

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MOLY

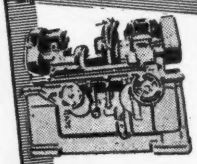
Here's What NORTON Makes . . .

ABRASIVE PRODUCTS

Grinding wheels ranging from tiny internals 3/16" x 3/16" to gigantic ten-ton pulpstones — wheels of Alundum*, Crystolon* and diamond abrasives, of many different bonds; abrasive bricks, sticks, hones and segments; mounted points and mounted wheels; abrasive grain for polishing, lapping and tumbling.

GRINDING and LAPPING MACHINES

Norton cylindrical grinders range from the neat, compact 4 x 12" Type C to the gigantic 36 x 816" Type D and include special types for grinding crankshafts, camshafts, rolls and car wheels. Norton surface grinders are available in three sizes, 6", 10", and 12". There are three Norton Tool and Cutter Grinders and the Norton Bura-way. Lapping machines for flat and cylindrical work including crankshafts and camshafts range from the small 10-U to the large Hyprolap*.

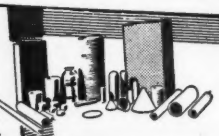


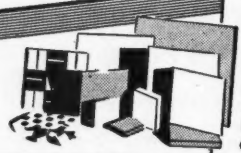
NORBIDE*

"The hardest material made by man for commercial use"— that is NORBIDE*, the trade name for Norton Boron Carbide. It is serving industry in three forms: (1) Norbide Abrasive for grinding and lapping carbide tools, and for lapidary work; (2) Norbide Molded Shapes for pressure blast nozzles and for plug, ring and other types of gages; (3) Norbide Metallurgical Compound for improving the hardness and cutting ability of tool steels and as a deoxidizing agent.

REFRACTORIES

The terrific heat of the electric furnaces which produce Alundum and Crystolon abrasives also gives these materials valuable refractory properties — properties which are made use of in a complete line of Norton refractory grain, cements, bricks, plates, tiles and other shapes for metal melting and heat treating, for enameling furnaces, ceramic kilns, boiler furnaces; also refractory laboratory ware for ignition, incineration and filtration.



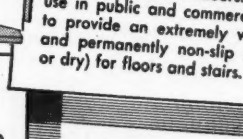


NORTON FLOORS

The hardness, toughness and abrasive properties of Alundum abrasive are made use of in NORTON FLOORS — Alundum Stair and Floor Tile, Alundum Ceramic Mosaic Tile and Alundum Aggregate for terrazzo and cement floors. They are for use in public and commercial buildings to provide an extremely wear-resisting and permanently non-slip surface (wet or dry) for floors and stairs.

OILSTONES and COATED ABRASIVES

Sharpening stones in sizes and shapes to meet every need of the industrial worker, the farmer and the home craftsman; and abrasive paper and cloth in a wide variety of coatings and types for both industry and the home mechanic are available through Behr-Manning Corp., Troy, New York, Division of Norton Company.



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Informative literature on any or all Norton products gladly sent on request—no obligation.

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NORTON

College News

(*Continued from page* 34)

from the University of Missouri and the M.S. in 1943 from the University of Colorado.

Electrical Engineering

Joining the faculty of the School of Electrical Engineering is Clyde E. Ingalls, associate professor of electrical engineering. Mr. Ingalls received the E.E. degree at Rensselaer Polytechnic Institute in 1927, and served as instructor there in electrical engineering, physics, and communications until 1929. Until 1941, he was successively radio engineer, head of the research laboratory, and head of the instrument development laboratory of Stromberg-Carlson Company in Rochester. During the war he was a staff member of the M. I. T. Radiation Laboratory, and has recently been a private consulting engineer.

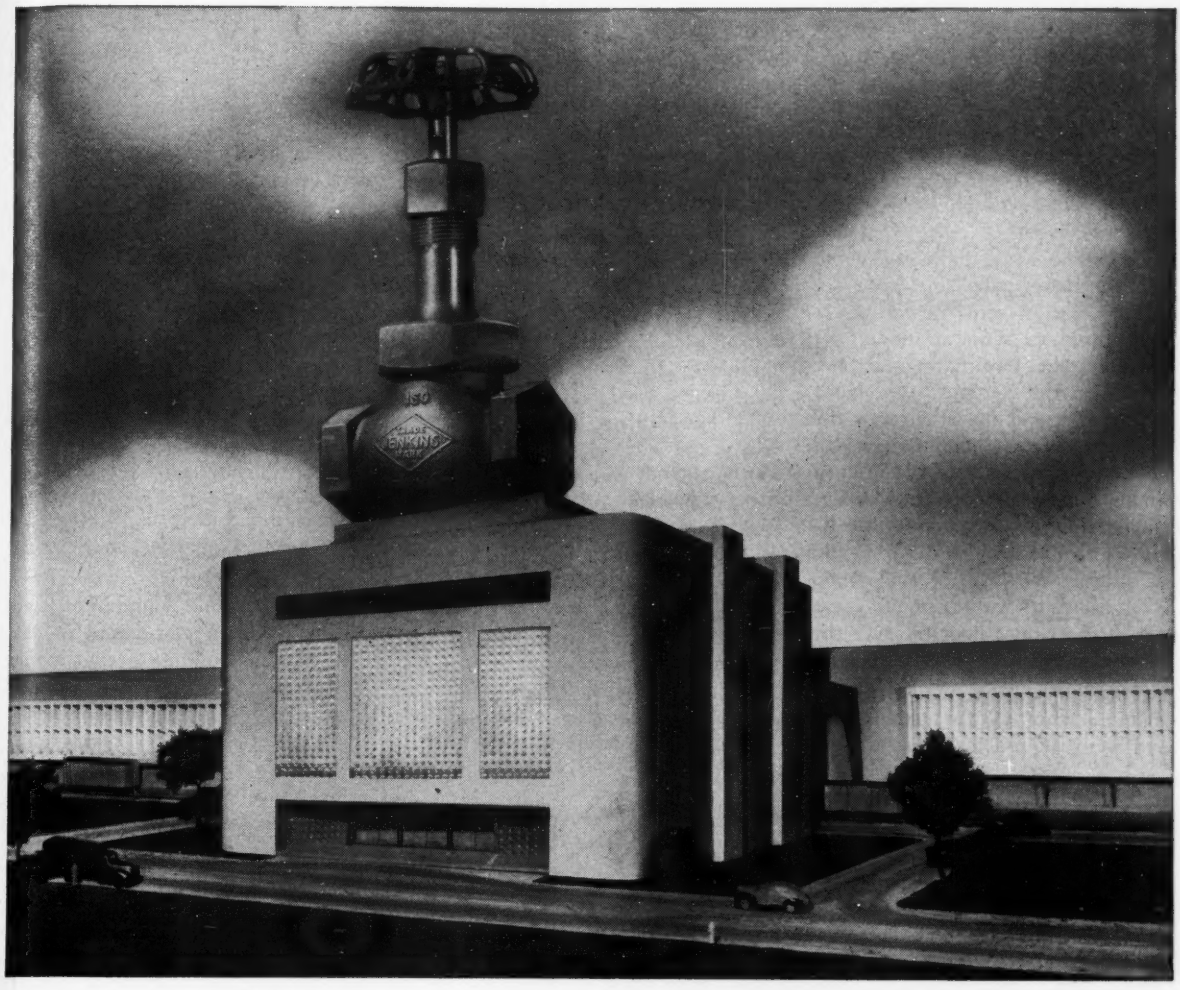
New Skyscraper

(*Continued from page* 13)

grits are used instead of cinders. A chemical is put into the mix which has a yeast-like effect when poured into the forms. The arch is poured 3" deep and the chemical process raises it to 4" thick. It adds to the soundproofing qualities and is a better protective covering for the steel than cinder arches.

Story heights in office buildings heretofore built are from 10'-8" to 11'-0". To allow for air conditioning ducts the story heights were made 11'-4½". A preliminary design of the air conditioning duct system indicated that where certain deep girders were used ducts could be run through the webs of the girders at the point of zero shear to save headroom. However, a further study revealed that some of the ducts would be so wide that too much of the web would be affected. That left a choice between wasting steel by making the framing shallower or increasing the story heights and losing an entire floor. It was decided, therefore, to redesign some of the girders and beams using wide flange sections. Seven hundred additional tons of steel were added in the re-design.

(*Continued on page* 38)



There's Truth in this "Tall Story"

IF YOU THINK of *all valves* in this plant as *one valve*, you'll see the truth in this trick photo. Valves, collectively, represent one of the biggest investments in equipment in any plant.

With wages and material costs highest ever, it is just as important for management to keep a sharp eye on valve maintenance as it is on operating costs of larger plant units.

EXCESSIVE MAINTENANCE of one inferior valve is insignificant, but, multiplied by thousands, it is a serious drain on operating budgets.

JENKINS BROS. helps management meet this problem two ways. First, by building extra endurance into Jenkins Valves, making them the longest-lasting, lowest-upkeep valves that money can buy. Second, with advice from Jenkins Engineers on any question of proper selection, installation, or maintenance.

That's why, for all new installations, for all replacements, alert management relies on Jenkins quality and engineering service for lowest valve costs in the long run. *Sold through leading Industrial Distributors everywhere.*

Jenkins Bros., 80 White St., New York 13; Bridgeport, Conn.; Atlanta; Boston; Philadelphia; Chicago; San Francisco.
Jenkins Bros., Ltd., Montreal.

"PREVENT VALVE FAILURE" is a 28-page guide to valve economy, fully illustrated, with case histories of valve damage, and recommendations for its prevention by proper selection, installation, inspection, and maintenance. FREE on request. Write JENKINS BROS., 80 White St., New York 13, N. Y.

LOOK FOR THIS DIAMOND MARK

SINCE Jenkins Bros 1864

JENKINS VALVES

Types, Sizes, Pressures, Metals for Every Need

New Skyscraper

(*Continued from page* 36)

This factor together with the strut system and the heavy spandrel sections over the store fronts resulted in a total of 4200 tons of steel, or almost 24 pounds per square foot of slab area.

The usual ceiling, base and switch outlets were provided but as a special precaution some of the floors were equipped with an underfloor duct system terminating in two outlets on the columns, one placed switch high and the other near the top from which ceiling outlets could be run. Until it was determined where hung ceilings would be installed there was no way of knowing whether the ceiling outlet would be at the arch level or the ceiling level. The horizontal ducts were run in the cinder floor fill over the arch. The fill is 3″ thick with a 1″ cement finish over.

In addition to the usual mens' and womens' toilets it was expected that some tenants would require private toilets and lavatories. Therefore, three "wet" stacks, consisting of soil, vent, and hot and cold water lines were run up along three columns in the loft area.

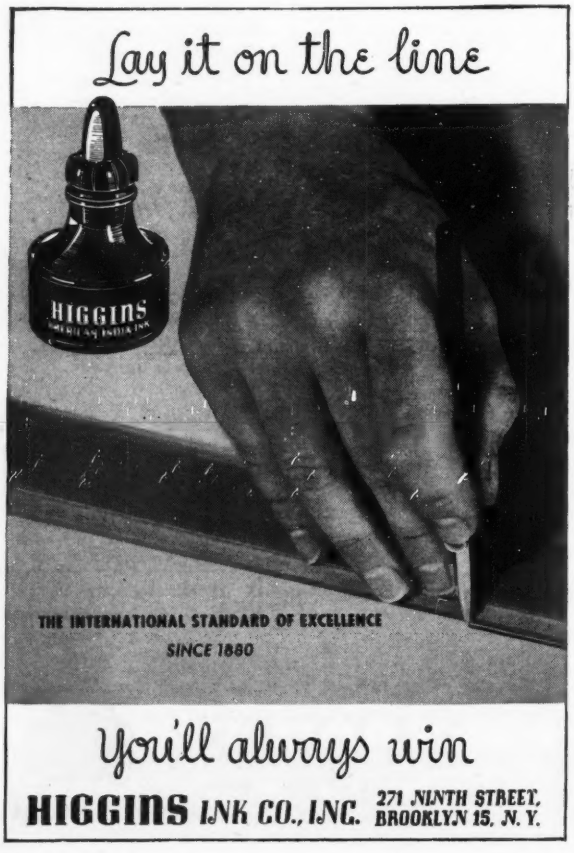
Building Dimensions

The building has a net cube of 4,300,000, the gross slab area is 350,00 square feet and the wall area above grade is 144,000 square feet.

It has been customary in office buildings to keep rentable space within 20′ to 22′ from a window. The lower floors of this building cover the entire lot area of 200′ x 90′. Part of the interior space is used for stair and elevator shafts, toilets and fan rooms. However, there is a substantial area of interior space left. Heretofore such space has been a drug on the market. However, with air conditioning, fluorescent lighting and the use of bank partitions, internationally known tenants have taken and are utilizing the space on 21-year leases.

As usually happens in an investment building enterprise of this type, the demolition of existing buildings started as soon as title was taken to the land and before working drawings were really underway. Because the wrecker got there first, taking of borings had to wait. When the wrecking was approaching completion, the working drawings were well along, and foundation and excavation drawings were completed. The urge was strong to step right in with the digging. Time was found to sneak in a few borings and rock was found approximately where preliminary studies indicated, namely, at 40′ plus or minus below sidewalk. The old building on the northerly half of the site was a 12-story apartment building, constructed early in the century. The foundation plan of this building was found in the files of the Building Department. The structural engineer spotted the new columns to duck the old ones

(*Continued on page* 40)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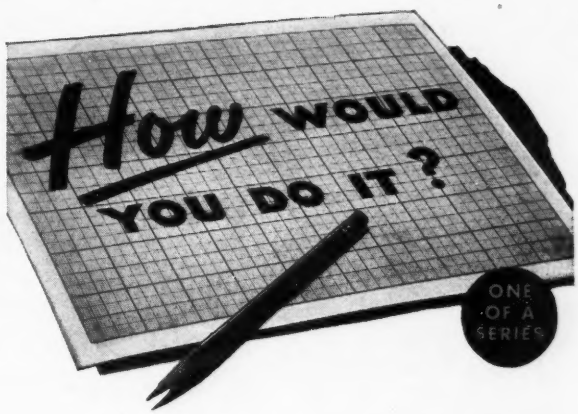
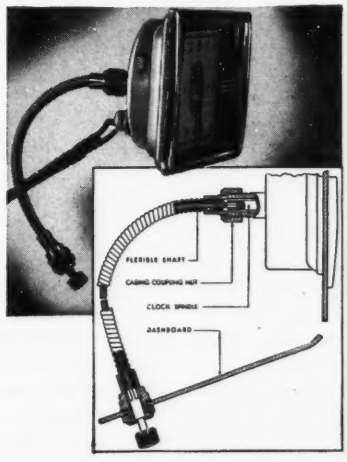
THE SPORT SHOP



PROBLEM—You are designing an electric clock for automobiles. The clock itself is completed. To set the clock, the spindle which turns the hands must be pushed in against a spring pressure and then turned—and, of course, when the clock is installed, this spindle is back under the dashboard. You want to provide a means for pushing and turning the spindle from a point that is easy to get at. How would you do it?

THE SIMPLE ANSWER—Use an S.S.White flexible shaft. The illustrations show how one manufacturer does it. Regardless of where the clock is mounted, the flexible shaft, available in any length, makes it possible to put the hand-set knob in the most convenient spots.



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This is just one of hundreds of power drive and remote control problems to which S.S. White flexible shafts are the simple answer. That's why every engineer should be familiar with the range and scope of these "Metal Muscles"* for mechanical bodies.

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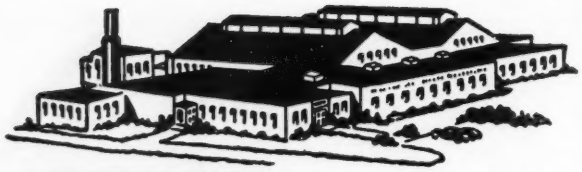

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They do it in the new plant of the Southern States Eastern Shore Marketing Cooperative, at Salisbury, Md. • Here 56,000 birds are kept on hand; the entire daily pack is cooled to 35°F, and half the chickens are quick-frozen at minus 35°. One of the storages is kept at 32°, the other at minus 5°; each holds 200,000 lb. of poultry. Up to 25 tons of ice are made per day, for precooling and shipping purposes. • Frick Refrigeration handles all the cooling work. If you want to be "in the know" on the latest quick-freezing methods, write for Frick Bulletin 147-B.

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We have recently secured a new business system which will enable us to give you a copy of all of your transactions so that you will know at all times, the books which you have purchased, their prices, and the time and term for which you secured the books.

It is realized that it was rather difficult to perfect the IBM system in one semester and that mistakes were made by all parties concerned—and that does not exclude ourselves. For our errors, we apologize.

We have always known that students cooperate to the fullest when the problems are explained to them.

Our motto is simple: "He profits mos twho serves the best."

May we continue to serve you as we have served Cornell students and faculty for the past forty-five years.

◆ ◆ ◆

TRIANGLE BOOK CO-OP

New Skyscraper

(*Continued from page* 38)

except at the corners. Rock was reached at approximately 40′ but it was soft rock and in vertical layers. The column piers had been designed for 50-ton bearing so we had to keep going and, in some cases, to 60′ or more below sidewalk. Even then some of the piers had to be splayed because even at the greater depths the rock was good for only 25 tons.

When the pier holes on the northerly half were opened up, it was found that practically every one was obstructed by a mass of concrete and encased steel grillages. Workmen chipped concrete and burned steel day in and day out to depths up to 15 feet.

The mystery can only be explained as follows—The piers for the old building, as originally designed and filed with the Building Department, were intended to reach bearing on an arbitrary load per square foot. After excavating to the depths intended, poorer soil conditions were encountered than was expected. Without filing new plans, permission was granted to tie in all the piers to each other by cross beams as a substitute for going to rock. Irrespective of the theory on which this was done, the building stood up through the years and was a tough one to demolish.

Scarcities

The necessity for continuity of operation and approximate adherence to time schedules required ingenuity and perseverance. A long list of materials was in scare supply, doled out under quota systems and delayed by intermittent strikes. The competition for rock drillers, steel erectors, riveters, and carpenters was so keen that only a partial quota of men could be obtained and then only by instituting a 48-hour week with 8 hours at overtime pay. The materials accumulated, paid for and stored in advance, was a major contribution to orderly progress. Soil pipe and fittings, form lumber, galvanized iron for ducts, roof insulation, wire mesh for concrete floors, metal lath, face brick, partition block, radiators, plumbing fixtures, copper for flashings, glass, limestone and marble had to be taken care of in this manner. Expedition of fabricated materials, ordinarily assigned to the purchasing and traffic departments, was undertaken by the best selling talent in the organization.

Operations of the type under discussion have recently been decontrolled from the authority of the Civilian Production Administration and are, therefore, not a current factor. However, on this particular operation it was a very important and disturbing factor as the license to proceed was not granted until after 2600 tons of structural steel cut to length had been delivered at the fabricating shop.

At the time the plans for the building were filed with the Department of Housing and Buildings, and an application made for a building permit, there was a suit pending in the State courts to test the constitutionality of the new Zoning Law as it applied to a retail district. The lower court had already ruled that the new Zoning Law was defective

(*Concluded on page* 42)

This girl can beat 50 monks to a standstill

Nowhere in the world are elevators as luxurious—efficient—and safe—as in America. Nowhere are such ingenious improvements made so consistently . . . so rapidly.

The ancestor of elevators—a crude basket attached to the end of frayed rope—*still* is in daily use—the only access to some monasteries in Greece. Powered by monks, fifty of whom could not do what a little slip of a girl does with one hand, these "elevators" try the nerves of brave men.

American ingenuity, born of individual enterprise, and nurtured by free competition, not only gave us the world's best elevators, it gave us a great industry employing thousands of men and using the products of a score of other industries.

The wire rope industry is not among the least of these.

Roebling engineers have kept pace with the designers of "lifts" ever since the first American elevator was installed with a Roebling elevator rope —back in the early 1860's.

Today, Roebling Special Traction Steel Elevator Rope enjoys the well-earned confidence of hoisting engineers the world over.

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New Skyscraper

(*Concluded from page* 40)

in this respect and the City was appealing to the higher court. The new law provided for approximately 72% coverage of the lot area on the ground floor whereas the old law allowed a 100% coverage. The upper floors were correspondingly affected. The owners took a calculated risk. The structure was designed and plans filed under the old law. The Building Department granted an approval contingent on the final result of the litigation. The final Court of Appeals ruling which threw out the new law was issued within a few days of the start of erection of the columns at the site.

All's well that ends well. In meeting and successfully surmounting the complex problems that accompany the development of a monumental structure under current conditions, it was possible to provide a building that not only stands out architecturally in the New York scene, but provides a large area of office space at a time when it is most critically needed.

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ITHACA, N. Y.

STRESS and STRAIN...

In London they were discussing advertising. "Great stuff, these electric signs on Broadway," said the Yankee. "There's one, advertising Wrigley's gum, that runs a whole block, and has 250,000 electric bulbs."

"How many?" asked the astonished Londoner.

"250,000," repeated the Yankee.

"But I say, old chap," cried the Londoner, "Isn't that a bit conspicuous?"

* * *

In the days of Queen Elizabeth, 'tis said, some of the ladies of the court liked to curl up with a good book, while others preferred individual pages.

* * *

The boat was sinking, and the skipper rushed up to a bunch of frightened passengers.

"Who among you can pray?" he asked.

"I can," replied a minister.

"Then you start praying, mister," ordered the skipper, "and the rest of you put on life preservers. We're one short."

* * *

He mumbled a few words in church
And he was married.
He mumbled a few words in his sleep
And he was divorced.

* * *

"Your girl is spoiled, isn't she?"
"No, it's just the perfume she's wearing."

* * *

ADVICE TO THE NEW GRADUATE

Don't worry if your job is small,
And your rewards are few;
Remember that the mighty oak
Was once a nut like you.

I was struck by the beauty of her hand.

I tried to kiss her.

As I say, I was struck by the beauty of her hand.

* * *

There she sat, surrounded by a score of her admirers. Her beauty was beyond description, but her haughty mien frightened away the less intrepid. As the music started again, the timid youth lurking in the background darted forward.

"Pardon me, Miss, may I have the next dance?"

"I'm sorry, but I never dance with a child," she said with an amused smile.

"Oh, a thousand pardons!" the youth replied, "I didn't know your condition!"

* * *

Jack had money.
Jill had nil.
Jill married Jack.
So Jack had Jill.
Jill went to Reno.
Now she's back.
Jack has nothing,
But Jill has jack.

* * *

She was only a gravedigger's daughter, but you should have seen her lower the beer.

* * *

The telephone linemen were working in front of the home of a spinster. She called the police complaining that the men were using profane language. The Chief of Police investigated. "It was like this, Chief, Me and Spike was aworkin' on this line. I was up on the pole. Spike was on the ground. I accidentally let a spoonful of hot lead fall down on Spike's neck and he looked up to me and said, 'Really, Harry, you should be more careful'!"

Inmate No. 746 of the alcoholic ward fingered his electric flashlight lovingly. "If I turn this beam straight up in the air," he said to inmate No. 747, "I'll bet you a trillion dollars you can't climb up it."

"I'm wise to your tricks," sneered No. 747. "I'd get halfway up and you'd turn it off."

* * *

Freshman: "Do you think a person is crazy if he talks to himself?"

Prof: "I don't think he's crazy if he talks to himself. But he is if he listens."

* * *

Definitions: A lazy student is one who pretends he is drunk so his buddies will put him to bed.

* * *

We're broom mates,
We sweep together,
Dust we two.

* * *

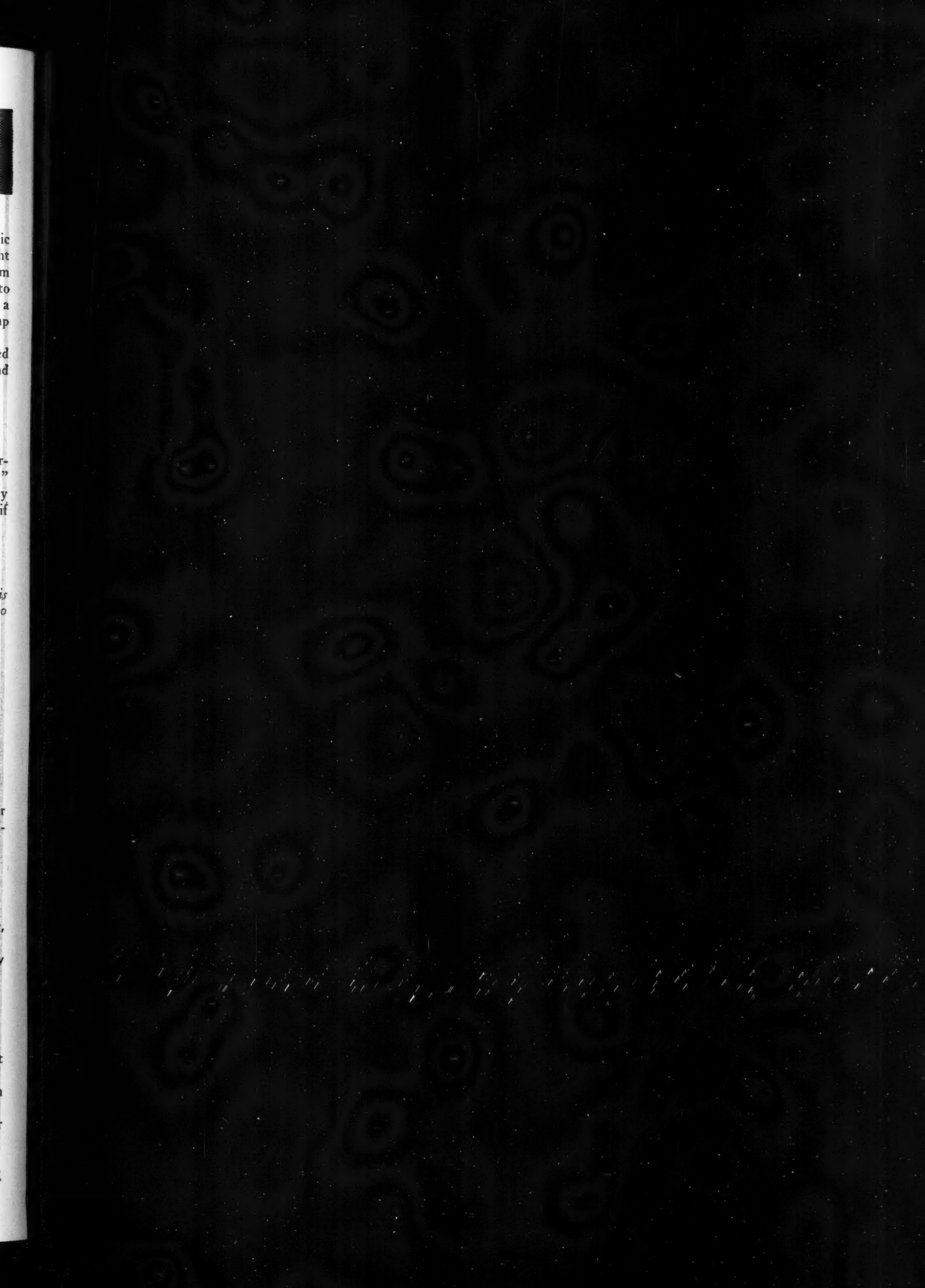
And lastly there was the engineer who called his girl discontinuous integral because she had no limit.

* * *

Gather your kisses while you may,
Time brings only sorrow;
For the girls who are so free today
Are the chaperones tomorrow.

* * *

"Shay, lady, you're the homeliest woman I ever saw."

"Well, you're the drunkest man I ever saw."

"I know, lady, but I'll get over it in the morning."